NOTICES

OF THE

# PROCEEDINGS

AT THE

MEETINGS OF THE MEMBERS

OF THE

# Royal Institution,

WITH

ABSTRACTS OF THE DISCOURSES

DELIVERED AT

THE EVENING MEETINGS.

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VOL. I.

1851 — 1854.

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## 1851.

[FOR THE USE OF MEMBERS.]

# Royal Institution of Great Britain.

1851.

WEEKLY EVENING MEETING,

Friday, January 24.

SIR R. I. MURCHISON, Vice-President, in the Chair.

PROFESSOR FARADAY

## *On the Magnetic Characters and Relations of Oxygen and Nitrogen.*

IN a Friday Evening discourse on the diamagnetic condition of flame and gases, delivered on the 14th April, 1848, Mr. Faraday called attention to the singular condition of oxygen gas in its relation to the magnet. It was then demonstrated that this gas was magnetic by its carrying a cloud of muriate of ammonia (itself diamagnetic) to the poles of the magnet, around which it seemed to gyrate in vortices. A more elaborate paper on the same subject had previously appeared in the Phil. Mag. for December, 1847.

Last year M. Becquerel, not aware of these researches, had rediscovered the high magnetic character of oxygen, made some independent investigations, and derived numerical results from them. These inquiries Mr. Faraday does not consider to interfere with, but strongly to confirm his own.

Oxygen is one of the most remarkable of known bodies: it forms one half of the aggregate of all matter. Important as are its magnetic properties, it seems incapable of receiving permanent magnetism like steel or the natural loadstone.—By a series of elementary experiments the audience were led to discriminate between these bodies, and soft iron, nickel, cobalt; which unless while under an extraneous magnetic influence, have no attractive force. Oxygen being of the latter class, it is not certain that, even while it possesses an attractive power, it is in the exact condition of the permanently magnetical body from which it derives it.

Were oxygen highly magnetic in the same extent as iron is, the immense quantity of magnetic power which would in that case be constantly undergoing variation by combustion, respiration, &c., would cause the most serious disturbances in nature. It is necessary to the conservation of the present state of things that the magnetic power in a given bulk of oxygen should be comparatively small. The audience were therefore told to expect no great demonstration of magnetism; but the extent to which that power does exist in oxygen and air, was proved by the following experiments:—

A double cone of iron (the apices of the cones meeting in a point, and the cones being equal and similar,) was fabricated of such a length as to complete the magnetic circuit when placed between the poles of the large electro-magnet in possession of the Royal Institution. Mr. Faraday directed attention to this hourglass-shaped piece, and showed how, by such an arrangement, extreme power is exerted at the place without any chance of change in the form of the parts. Very small soap-bubbles were blown by means of a glass tube drawn to a fine point, from a bladder filled with oxygen. It was observed that these bladders so filled were drawn forcibly inwards to the apices of the cones, but that no such effect followed when bubbles were filled with nitrogen. Another experiment, which was visible all over the room, at once demonstrated the same fact, and illustrated a differential mode of measuring the magnetic force of oxygen. A delicately balanced wire was suspended from its centre of gravity by 10 fibres of the cocoon of the silk-worm; from the extremities of a small cross bar at one end of this wire were hung small glass bubbles; and the whole was so adjusted that the bubbles were on opposite sides of the apices first described, each hanging near to it but not in contact with the iron, and each equidistant from it. Therefore any difference of magnetic influence on the bubbles or their contents would be indicated by the bubble so affected being drawn inwards. In order to render such motion widely visible, the other arm of the balance just described was converted into a long indicating lever, constructed of a straw for the sake of lightness. To the extremity of the longer end a slip of silk was attached to catch the eye, and the lever was shielded from the currents in the room by being placed within a glass balloon two feet in diameter. By the motion of the lever it was seen, when one of the bubbles was filled completely or partially with oxygen and the other with nitrogen, that nitrogen, whether dense or rare, was totally unaffected by the magnet, and that oxygen was magnetic in direct proportion to its density in the bubble; and that the force required to set the bubble of oxygen (one atmosphere) in motion towards the magnet was one-tenth of a grain for one-third of a cubic inch of oxygen.

Certain peculiarities in the exertion of the power which is here in action, not as a central, but as an axial force, were then referred to.

The inference from the experiment, supported by other experiments on bubbles containing air, is — that as oxygen enters into the atmosphere in a constant proportion, and as the magnetic power of oxygen varies directly with its density, definite variation must take place in the magnetic power of the atmosphere in different states.

Mr. Faraday was led to inquire whether any separation of oxygen from nitrogen in a mixture of these gases could take place, as happens when a magnet is presented to a mixture of iron filings and sand. To test this idea he applied to the conical angle (so often de-

scribed as the centre of magnetic force,) a glass tube drawn to a point (as in the apparatus used for blowing the delicate soap-bubbles,) and filled with water; by slowly withdrawing the water, the air could be drawn into the tube from any desired spot and tested. This was done; and it was found that even when the magnetic action was most intense, the proportions of the magnetic oxygen and of the non-magnetic nitrogen were undisturbed.—The following experiment proved that no condensation was produced on oxygen by the magnetic power, *i. e.* that it is not aggregated, as happens with iron filings when under the influence of the magnet. The flat-faced poles of the magnet were separated the 60th of an inch by a copper plate with an aperture in the middle, so that when the whole was clamped together a chamber was formed. By gauges attached to this chamber it was found that no trace of condensation occurred, however great was the magnetical force brought to bear on the oxygen.

The loss of magnetical power occasioned by heat was then noticed. This was shown first in the case of iron heated to redness; then in that of nickel raised to the temperature of boiling oil; and lastly, in the case of the air (*i. e.* of the oxygen in this air) by the following experiment:—Two conical poles a little separated were employed; above was placed a piece of phosphorus on paper, and below a helix of platinum wire heated to redness by a small Grove's battery independent of that used to excite the electro-magnet. The heated air, rising upwards from the helix, speedily inflamed the phosphorus above it whilst the electro-magnet was unexcited; but when rendered active, the oxygen in the heated air becoming less magnetic, was displaced by the current of colder (and consequently more magnetical) oxygen, and the phosphorus in consequence remained unaffected by the mass which glowed beneath it, until the electro-magnet was deprived of its power; and then the natural laws of specific gravity came again into operation, the heated air rose, and the phosphorus was lighted.

In conclusion, Mr. Faraday announced his intention of applying, on a future evening, the reasoning deducible from these and other experiments, to the variation of magnetic lines on the earth's surface. His purpose then will be to compare the records of this varying force with the variations of temperature occasioned by the annual revolution of the earth, the varying pressure of the atmosphere, storms, &c. with the hope of supplying a true theory of the cause of the annual and diurnal, and many of the irregular variations of the terrestrial magnetic power.

For the papers in which these results are described more at large, see Philosophical Magazine, 1847, Vol. XXXI. p. 401; and Philosophical Transactions for 1851, p. 1.

Among the objects exhibited in the Library, were—a water-worn Lump of Gold, (weight 219 oz. 8 dwt. 12 gr.; value about £826,) from Carson's creek, California [by the Governor of the Bank of

England]—an Ingot (weighing 324 oz.) and a cup of chemically pure Palladium [by Mr. G. Matthey]—Specimens of Printing in Colours, by Wood-blocks and Lithography [by Messrs. C. and G. Leighton]—Henley's Magneto-Electric Telegraph, &c. &c.

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## WEEKLY EVENING MEETING,

Friday, January 31.

W. Pole, Esq. F.R.S. Vice President, Treasurer, in the Chair.

Professor Brande

*On Peat and its Products.*

Referring with commendation to an article entitled "The Irish California" in Dickens's Household Words, No. 41, p. 348, Professor Brande disclaimed any purpose of predicting the result of the great enterprize which is described in that able paper. He proposed to confine himself to a statement of what had been done, and what was doing, to make the products of peat commercially valuable.

A peat bog was described as a superficial stratum of vegetable matter, which at different depths is undergoing, or has undergone, various stages of change and decomposition. Its superficial appearance is that of a mass of half-decayed mosses, rushes, heath, and grass; the roots having successively died away, though the plants continued to vegetate. The mass is ligneous, and imbued with humus and humic acid, among other products of slow decay; and the abundance of moisture pervading the bog affects the character at once of the peat and of the district. The upper layers of the bog are usually loose and fibrous, and of a pale brown colour. Beneath the surface the density is found to increase, sometimes to a great extent. At last, the distinctive characters of the vegetables cease to be discernible, and the mass appears nearly homogeneous, and of a dark brown, or blackish colour. Trunks of trees, and some curious geological phenomena, occasionally present themselves. A peat district may be regarded therefore as the consolidated produce of enormous forests and fields of vegetation, amounting in the aggregate to millions of acres. In Ireland alone $\frac{1}{10}$th of the surface is covered by peat bog, which if removed would exhibit a soil fit for the operations of agriculture.

Professor Brande then invited attention to different samples of peat taken from the upper, middle, and lower portions of the bog. He particularly noticed the tallow peat of the banks of Lough Neagh, which, from the brilliant flame attending its combustion, is sometimes used as a source of light as well as of heat.

Peat may be rendered valuable, either

1. From the charcoal which may be obtained from it; — or

2. By the various products derivable from what is called its destructive distillation.

When it is desired to convert peat into charcoal, the plan adopted by the Irish Amelioration Society is to carbonize blocks of peat, partially dried on trays of wicker work, in moveable pyramidal furnaces. The charcoal so obtained varies in character with that of the peat which produces it; and when the peat is compressed previous to its carbonization, (which may be well effected by means of a machine invented by Mr. Rogers, and which was explained by reference to a diagram,) the resulting charcoal exceeds the density of common wood charcoal. In stove-drying, dense peat loses about one-third, and the light and porous, half of its weight: 4 tons of dried peat will give about one ton of charcoal. The efficacy of this charcoal in the manufacture of iron, in consequence of the small quantity of sulphur it contains, was mentioned; and its deodorizing and purifying qualities experimentally exhibited.

2. *The products of the destructive distillation of peat* were then described. The elements of peat are essentially those of wood and coal; viz. Carbon, Nitrogen, Hydrogen, and Oxygen. If therefore peat were distilled in close vessels, the products obtained, would, as might be expected, resemble the products of a similar operation on coal or wood. Hitherto, however, the expense of such a process in the case of peat has precluded its general adoption. Mr. Reece however has invented for this purpose a blast-furnace, which differs in principle from that in which iron is melted, by having an arrangement to collect the products of combustion; and he has thus succeeded in obtaining ammonia, acetic acid, pyroxylic spirit, tar, naphtha, oils, and paraffine, together with large quantities of inflammable gases, from the peat. It has been found convenient to place two of these furnaces close to each other, so that one may be at work when the blast is turned off the other in order to allow of its being charged.

In two furnaces of this kind, 10 feet in diameter and 35 feet high, 100 tons of peat may be decomposed every 24 hours,

and produce 10,000 gallons liquor (A.)
1,000 . . tar (B.)
6,270,000 cubic feet of inflammable gases (C.)

A. The liquor holds in solution sufficient ammonia to yield when saturated by sulphuric acid 1 ton of sulphate of ammonia; enough acetic acid to give, when saturated by lime, 14 cwt. of grey acetate of lime; and, lastly, it contains 52 gallons of pyroxylic spirit. This process was described in detail, and a diagram of the furnaces, and of the apparatus employed for distilling the spirit was exhibited.

B. The tar is quite different from what is obtained from coal or from wood. It is a peculiar greasy-feeling substance. This substance is heated to about 100° at which temperature it melts; and being then treated first with about 3 per cent. of sulphuric acid, and afterwards with hot water, it separates after a time, into two

layers; the lower consisting of acid, water, and impurities; the upper, of paraffine and oils.

This mixture of paraffine and oily hydrocarbons is then submitted to distillation: the first half of the distilled products consists chiefly of hydrocarbons of the naphtha family; the other half contains the denser oils and paraffine; when cold, the paraffine crystallises, and is separated from the oil by straining and pressure; it is subsequently bleached and deodorized by chlorine, or chlorochromic acid; then redistilled, pressed, and steamed, until brought to a state of purity. The heavy oils, from which the paraffine is deposited, are then mixed with the lighter oils, which were separated in the first instance by distillation, and with caustic lime. After a time sulphuric acid is added, which combines with impurities. The oils are then distilled, bleached by chlorochromic acid, and deodorized. In this part of the process the substance called *capnomor*, the properties of which have not been investigated, presents itself.

C. *The gases.* — The greater part of the oxygen of the air which is blown through the furnace, naturally combines in the first instance with the burning carbon and is converted into carbonic acid. This gas, however, on rising through the intensely heated mass, takes up an additional proportion of carbon to form *carbonic oxide*, which passes off with the hydrogen and gaseous hydrocarbons, also generated by the combustion, and which, notwithstanding the large proportion of nitrogen blended with them, remain in the form of an inflammable mixture, which is ultimately used as fuel to work the steam-engine, and to heat the stills and boilers.

In conclusion Professor Brande reviewed the various products of peat and their uses.

They appear to be.

1. *Sulphate of Ammonia.* This substance is employed in the preparation of carbonate and muriate of ammonia, of caustic ammonia, and in the manufacture of manures and fertilizing composts.

2. *Acetate of Lime,* which is in constant demand as a source of acetic acid, and of various acetates largely consumed by the calico printers.

3. *Pyroxylic spirit* (*or wood-alcohol*) used in vapour lamps, (two of which were exhibited and attention called to the brilliancy of the light afforded,) and in the preparation of varnishes.

4. *Naphtha,* used for making varnishes, and for dissolving caoutchouc.

5. *Heavy and more fixed oils,* applicable for lubricating machinery, especially when blended with other unctuous substances; or as a cheap lamp oil, and as a source of lamp black.

6. *Paraffine.* This when mixed with fatty matter forms a material for candles, samples of which were shown, consisting of mixtures of paraffine, sperm, and stearine.

## GENERAL MONTHLY MEETING,

February 3, 1851.

SIR CHARLES FELLOWS, Vice-President, in the Chair.

Capt. H. J. Codrington, R.N., and W. T. Dry, Esq., were *admitted* Members of the Royal Institution.

William Bevan, Esq.
Allen Davis, Esq.
The Earl of Ducie,
The Countess of Ducie,
J. P. Gassiot, Esq., F.R.S.
The Viscount Mandeville,
Adam Murray, Jun. Esq.
James Scott, Esq.

were duly *elected* Members of the Royal Institution.

The following PRESENTS were announced; and the thanks of the Members ordered to be returned for the same :—

FROM

*The Royal Institute of British Architects* — Proceedings for November, December, 1850; January, 1851. 4to.

*The Royal Geographical Society*— Journal, Vol. XX. Part 1. 8vo. 1850.

*The Institution of Civil Engineers* — Proceedings for November, December, 1850; January, 1851. 8vo.

*The Statistical Society of London* — Journal, Vol. XIII. Part 4. 8vo. 1850.

*John Webster, M.D., F.R.S., M.R.I. (the Author)* —An Essay on the Epidemic Cholera. 12mo. 1832.

Observations on the Admission of Medical Pupils to the Wards of Bethlem Hospital. 8vo. 1842.

On the Health of London during the six months terminating Sept. 28, 1850. 8vo. 1850.

Notes of a Recent Visit to several Provincial Asylums for the Insane in France. 8vo. 1850.

*Thos. Twining, Esq., Jun., M. R. I.*— Geschichte des Vereins für Naturkunde im Herzogthum Nassau, und des Naturhistorischen Museums in Wiesbaden; von Dr. C. Thomä. 8vo. 1842.

Jahrbücher des Vereins für Naturkunde im Herzogthum Nassau, 1844-50. 6 Hefte, 8vo.

*Athenæum Club* — List of Members, &c. 18mo. 1850.

Supplement to the Catalogue of the Library of the Athenæum. 8vo. 1851.

*A. V. Holtzapffel, Esq.*— Turning and Mechanical Manipulation, &c. by the late Charles Holtzapffel. Vol. III. 8vo. 1850.

*C. T. Jackson, Esq. (the Author)* — Report on the Geological and Mineral Survey of the Mineral Lands of the United States in the State of Michigan. 8vo. 1849.

*John Forbes, M.D., F.R.S., M.R.I. (the Author)* — Of Happiness in its relations to Work and Knowledge. 12mo. 1850.

*The Dowager Lady Stanley of Alderley* — An Account of the Hot Springs in Iceland, (accompanied by one large and four smaller Engravings,) by John

Thos. Stanley, Esq., F.R.S., with an Analysis of their Waters, by Joseph Black, M.D. 8vo. 1791.

*The Agricultural Society of England* — Journal, Vol. XI. Part 2. 8vo. 1850.

*W. Parker, Esq., M.R.C.S.* (*the Author*) — The Physiological and Scientific Treatment of Cholera. 12mo. 1849.

A Treatise on the Cause and Nature of Vital Heat. 12mo. 1850.

*W. Roxburgh, M.D., M.R.I.* — Medico-Chirurgical Transactions published by the Royal Medical and Chirurgical Society of London; Vol. XXIII—XXVI. 8vo. 1840-3.

*Professor Faraday* — Bulletins des Séances de la Classe des Sciences, de l'Académie Royale de Belgique, Année 1849. 8vo. 1850.

Structure and Classification of Zoophytes: by J. D. Dana, A.M. 4to. 1846.

Ausführliches Handbuch der Analytischen Chemie; von H Rose; 2 vol. 8vo. 1851.

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften, Wien; Juni und Juli, 1850.— Notizenblatt, No. 1. 8vo. 1851.

Archiv für Kunde Oesterreichischer Geschichts-Quellen; 1850, II Band, 1 und 2 Hefte. 8vo.

*The Editor* — The Athenæum Journal for December, 1850, and Jan. 1851. 4to.

*Jacob Bell, Esq., M.R.I.* (*the Editor*).—The Pharmaceutical Journal for Jan. and Feb. 1851. 8vo.

*The Chemical Society* — Quarterly Journal, No. 12. 8vo. 1851.

*The Asiatic Society of Bengal* — Journal, No. 213. 8vo. 1850.

*The Editor* — The Art-Journal for Jan. 1851. 4to.

*N. Bland, Esq., M.R.I.* (*the Author*) —Persian Chess. 8vo. 1850.

*W. Salt, Esq., M.R.I.* — Portrait of John Buckler, Esq., F.S.A. in 1847.—1850.

*W. Johnston, Esq, M.R.I.* (*the Author*) — England as it is, Political, Social, and Industrial, in the middle of the Nineteenth Century; 2 vols. 12mo. 1851.

*The Syndicate of the Cambridge Observatory* — Astronomical Observations made at Cambridge by the Rev. J. Challis; Vol. XVI. (1844-5). 4to. 1850.

*C. L. Prince, Esq.,* (*the Author*) — Results of a Meteorological Journal, kept at Uckfield, Sussex, in 1850. fol. 1851.

*The Horticultural Society of London* — Journal, Vol. V. Part 4, and Vol. VI. Part 1. 8vo. 1850.

*B. C. Brodie, Esq., F.R.S., M.R.I.,* (*the Author*) — On the Condition of certain Elements at the Moment of Chemical Change, 4to. 1850.

*G. B. Airy, Esq.* (*Astronomer-Royal*), Greenwich Astronomical, Magnetical, and Meteorological Observations for 1849. 4to. 1850.

*The Cambridge Philosophical Society* — Transactions, Vol. IX. Part 1. 4to. 1851.

*Professor Piazzi Smyth* (*the Author*)— On a Method of Cooling the Air of Rooms in Tropical Climates. 4to. 1850.

*T. Turner, Esq.,* (*the Author*)— Remarks on the Amendment of the Law of Patents. 8vo. 1851.

*The Senate of the University of London* — London University Calendar for 1851. 12mo.

*The Royal Medical and Chirurgical Society* — Medico-Chirurgical Transactions, Vol. XXXIII. 8vo. 1850.

## WEEKLY EVENING MEETING,

Friday, February 7, 1851.

The Duke of Northumberland, President, in the Chair.

Professor Owen

*On Metamorphosis and Metagenesis.*

The Lecturer commenced by passing under review the Linnæan characters of Minerals, Vegetables, and Animals, and the subsequent distinctions which had been proposed for the discrimination of the two latter kingdoms of nature. After discussing those founded on motion, the stomach, the respiratory products, the composition of the tissues, and the sources of nourishment, it was shown that none of these singly, define absolutely the boundaries between plants and animals; it requires that a certain proportion of the supposed characteristics should be combined for that purpose.

The individuals in which such characters are combined are specially defined members of one great family of organized beings, and the supposed peculiarly animal and vegetable characters taken singly, interdigitate, as it were, and cross that debatable ground and low department of the common organic world from which the specialized plants and animals rise; and there are numerous living beings with the common organic characters that have not the distinctive combined superadditions of either group.

Between the organic and inorganic worlds the line of demarcation may be more definitely drawn. The term 'growth' cannot be used in the same sense to signify the increase of a mineral and of an organism. The mode of increase is different: there is a definite limit to it in the organic kingdom, and something more than mere growth takes place in the progress of an organism from its commencement to maturity. This was exemplified by reference to the human subject, to the lion which acquires its mane, to the stag which gets its horns, and to the change of plumage in birds during the course of growth. The changes of form and character are still more remarkable in the kangaroo; and in the frog they are such as to have received the name of '*metamorphosis*.'

The development of the frog was traced to its exclusion from the egg in the form of a fish, with external gills, a long caudal fin, and without legs.

The internal skeleton, like the external shape, is adapted for aquatic life.

Only those parts are ossified which are to be retained in the mature state. The vertebræ are at first biconcave, as in fishes, with invervening spherical elastic balls filled with fluid: they are converted into ball and socket joints by the ossification of the sphere, and its anchylosis to the back part of the vertebræ. The pelvis and hind legs are progressively developed; and, whilst this change is proceeding, the tail is undergoing proportional absorption. The chief change in the skull of the larva is operated in the lower or hæmal arches and their appendages. The maxillary arch is widened and provided with teeth, and the horny mandibles are shed. The mandibular arch retrogrades as well as expands. The hyoidean undergoes a remarkable change of size and shape, and the branchial arches are absorbed, excepting a small portion which is converted into the hinder 'horns' of the hyoid for supporting the larynx.

The scapular arch, which at first was connected with the occiput, whilst supporting the branchial heart — its primary function, begins as soon as the fore-legs bud out, to retrograde, and the sternum is developed to complete the 'point d'appui' for the fore limbs.

The food of the larva is chiefly the soft decaying parts of aquatic plants; it has a horny beak, a long alimentary canal disposed in a series of double spiral coils: but, as its frame undergoes the changes adapting it for life on land, and a purely animal diet, the mandibles are converted into jaws and teeth, and the long spiral intestine into a short and slightly convoluted one.

Soon after the external gills have reached their full developement they begin to shrink and finally disappear; but the branchial circulation is maintained some time longer upon internal gills: by anastomoses between the principal branchial vessels these are converted into the aortic arches, carotids and subclavians; the internal gills with the cartilaginous hoops supporting them are absorbed, and lungs and glottis for breathing the air directly are developed.

Thus an animal formed for moving in water is changed into one adapted for moving and leaping on land; a water-breather is converted into an air-breather; a vegetable feeder into a carnivorous animal: yet the series of transmutations are limited to the nature of the species and produce no other. The frogs that croak in our marshes are as strictly batrachian as those that leapt in Pharaoh's chamber; their metamorphoses have led to nothing higher than their original condition, as far as history gives us any knowledge of it. With each successive generation the series of changes recommences from the old point, and ends in a condition of the animal adapted to set the same series again on foot.

Having traced the principal stages in the metamorphosis of an animal from a swimmer to a leaper; the Lecturer next took an instance

where one begins life as a burrower or a crawler, and is converted into an animal of rapid and powerful flight.

Most insects quit the egg in the form of a worm, which masking, as it were, a different and higher form, is called the 'larva;' it is active and voracious — but usually falls into a kind of torpor, during which the changes take place which issue in the flying insect; during the passive stage of metamorphosis it is called a 'pupa;' the last volant stage is the 'imago.'

The chief steps in the metamorphosis were traced as they affect the outward form, the digestive organs, the circulatory, and respiratory, and nervous systems.

The main differences in the metamorphoses of insects relate to the place where, and the time during which they are undergone. The young cockroach and the little aphis, which were first acephalous and apodal, and then had thirteen equal segments, with soft unjointed legs, proceed to acquire a distinct head with antennæ, a thorax with three pairs of long jointed legs, and an abdomen, before they quit the egg; they thus enter upon active life under the guise of a crab, instead of a worm. With regard to the *Aphis*, that insect, instead of proceeding to perfect its individual development, may at once begin the great business of its existence by parthenogenetic procreation. Bonnet's experiments, which first brought to light this marvellous fact, have received uniform confirmation from all subsequent enquirers, and no natural phenomenon is now better determined.

From seven to eleven successive generations have been traced before the individual has finally metamorphosed itself into the winged male or winged oviparous female.

In Autumn, when the nights grow chilly and long, the oviparous imago completes her duty by depositing the eggs in the axils of the leaves of the plant, where they are protected from the winter frost, and ready to be hatched at the return of Spring. Then recommences the cycle of change, which being carried through a succession of individuals and not completed in a single life-time, is a 'metagenesis' rather than a 'metamorphosis.'

This phenomenon which, until very recently was deemed an exception, and a most marvellous one, in Nature, now proves to be an example of a condition of procreation to which the greater part of organised Nature is subject.

The Lecturer was inevitably limited in his choice of illustrations: and proceeded to an instance of metagenesis from the radiated subkingdom of animals.

The stages of this metagenesis have been best and most completely traced in the *Medusa aurita*, by Siebold, Dalyell, Sars, and others.

The first step was made by Siebold who, in 1839, traced the development of the *Medusa aurita* from the egg to a stage resembling

a ciliated monad, then to a lobed rotifer, and next to a long-armed polype.

This polype stage of the *Medusa* had been previously recognised in 1788, but without a suspicion of its true nature, by O. F. Müller, who called it *Hydra gelatinosa*.

It was next observed, and its habits more fully described, by Sir John Dalyell, in 1834, as *Hydra tuba:* and in 1836 he made known its singular metamorphoses into forms which Sars had previously described as *Scyphistoma* and *Strobila;* and Dalyell saw the spontaneous division of the latter into a pile or series of small Medusæ. All the stages of the metagenesis were independently noted by Sars who described them in 1841.

The difficulty of accounting for the presence of Entozoa in the interior parts of animal bodies is rapidly disappearing as the knowledge of their course of development advances.

The principal stages of this development were described in a small worm (*Menostoma mutabile*), parasitic in the air-cells, intestines, and peritoneal cavity of many water-fowl.

The ovum is converted into a ciliated monadiform embryo, which escapes from the bird, and swims about freely in the water. A clear mass may be discerned in the interior which exhibits independent movements. This body is liberated, grows rapidly, and generates in its interior a number of independent organisms provided with a cephalic speculum and a caudal appendage, referable by their form to the genus *Cercaria.* They are very active and insinuating, could even bore through the skin by the sharp needle-like armature of the head, and somehow or other do, under the guise of the *Cercaria,* again get access to the interior of the water-fowl; fall into a state of torpor; become circular flattened pupæ; and are finally metamorphosed into monastomes — a sluggish pendant parasite utterly deprived of the power of existing in water, or of gaining access, as a monostome, to the interior of any animal.

Steenstrup, who has the merit of having first grouped together and pointed out the analogies of the different stages in the animals that undergo these successive changes, generalizes the facts under the phrase of 'Alternate Generation,' and he calls the procreant larvæ 'Amme,' or Nurses, and 'Gross-amme,' or Grand-nurses. There is no particular objection to these names; but we naturally desire to know on what power the metageneses depend.

Professor Owen thought the key to the power was afforded by the process which the germinal part of every egg undergoes before the embryo begins to be formed.

A principle, answering to the pollen, that fertilizes the seed of plants, is the efficient cause of these changes: its mode of operating is best seen in the transparent eggs of some minute worms; the principle manifests itself as a transparent, highly refractive globule

in the centre of the egg: it then divides; and each division, attracting the vitelline matter of the egg about it, divides that matter into two parts. This division is repeated with the same result, until the principle has diffused itself by indefinite multiplication through the whole yelk which then constitutes the 'germ-mass.'

The next stage is the formation of the embryo: certain of the minute subdivisions, called 'nuclei' or nucleated cells, combine and coalesce to constitute the tissues of the embryos: they are afterwards incapable of generating. If all be so metamorphosed the organism cannot procreate of itself; but if a part only of the germ-mass be metamorphosed into tissues, the unchanged remnant may, if nutrition, heat, and other stimuli are present, repeat the same actions as those that formed the first germ-mass, and lay the foundation of future embryos.

In proportion to the amount of the substance of an organism which retains the primitive condition of cells, is the power of producing new individuals without receiving a fresh supply of the pollen-principle.

Thus in a plant, when the seed has received the matter of the pollen-filament, analogous changes take place to those that have been described in the animal egg, and the embryo plant appears in the form of the cotyledonal leaf with its radicle or rootlet. From this shoots forth another leaf with its stem: and the cellular substance of the pith with its share of the pollen-principle goes on developing fresh leaves and leaf-stalks; until a provision for developing fresh pollen is made by transforming certain individual leaves into a higher form of the 'phyton' or elemental plant. Thus a generation or 'whorl' of leaves assumes the character of sepals, another that of petals, a third that of stamens, a fourth that of pistils: and in the two latter forms we recognize the analogues of the perfect male and female of the animal.

The development of the compound polype follows very closely the stages of the compound plant, which we call shrub or tree: the ovum, like the seed, having received the pollen-principle, is converted into countless cells and nuclei of cells by the process for diffusing that principle through, or of assimilating it with, the matter of the egg. Then certain germ-cells are metamorphosed into a ciliated integument, and the larva starts forth in a state answering to the cotyledonal leaf of the plant: the ciliated larva settles, subsides, and shoots up a stem from which a digestive polype is developed, answering to the leaf: but the pollen-force not being exhausted, a second branch and polype are developed, and so on until a preparation is made for a fresh supply of pollen-force, by metamorphosing the polype into a higher form of individual; and this, in many compound polypes, is set free in the shape of a minute medusa.

The true nature and relation of the individual polype to the compound whole is well illustrated by the propagations of the Aphides.

By comparing with the diagrams of the metagenesis of the plant and polype, that of the Aphis, in which was represented the corresponding stages intervening between the ovum and the perfect male and female individuals of the *Aphis*, the analogy between these stages in the plant, the polype, and the insect, was shown to be both true and close. The microscopic fertilizing filament of the male *Aphis* answers to the microscopic pollen-filament of the male leaf or 'stamen.' The ovum of the female *Aphis* to the ovule of the female leaf or pistil: by their combination the fertile ovum results. The same processes of cell-formation ensue, and the embryo *Aphis* is formed by the combination and metamorphoses of certain of these secondary germ-cells; but it retains the rest unchanged in its interior, which may be compared with the cells of the pith of the plant, and with the cells in the corresponding more fluid part of the pith of the polype. Under favourable circumstances of nutriment and warmth, certain of these cells repeat the process of embryonic formation, and a larval individual like that from the ovum is thus reproduced; which is only not retained in connection with its parent, because the integument is not coextended with it.

The generation of a larval Aphis may be repeated from seven to eleven times without any more accession to the primary pollen-force of the retained cells than in the case of the zoophyte or plant; one might call the generation, one by 'internal gemmation;' but this phrase would not explain the conditions essential to the process, unless we previously knew those conditions in regard to ordinary or external gemmation.

At length, however, the last apterous or larval Aphis, so developed, proceeds to be 'metamorphosed' into a winged individual, in which either only the fertilizing filaments are formed, as in the case of the stamens of the plant, or only the ovules, as in the case of the pistil. We have, in fact, at length 'male and female individuals,' preceded by procreative individuals of a lower or arrested grade of organization, analogues to the gemmiparous polypes of the zoophyte and to the leaves of the plant.

The process was described for its better intelligibility in the Aphides as one of a simple succession of single individuals, but it is much more marvellous in nature. The first-formed larva of early spring procreates not one but eight larvæ like itself in successive broods, and each of these larvæ repeats the process; and it may be again repeated in the same geometrical ratio until a number which figures only can indicate and language almost fails to express, is the result. The Aphides produced by this internal gemmation, are as countless as the leaves of a tree, to which they are so closely analogous.

It generally happens that the metamorphosis which has been described as occurring after the seventh or eleventh generation takes place much earlier in the case of some of the thousands of individuals so propagated: just as a leaf-bud near the root may develope a leaf-stem and a flower with much fewer antecedent generations of leaves from buds than have preceded the formation of the flower at the summit of the plant; or just as one of the lower and earlier formed digestive polypes may push out a bud to be transformed into a procreative and locomotive polype. The same analogy is closely maintained throughout.

The wingless larval Aphides are not very locomotive; they might have been attached to one another by continuity of integument, and each have been fixed to suck the juices from the part of the plant where it was brought forth. The stem of the rose might have been incrusted with a chain of such connected larvæ as we see the stem of a fucus incrusted with a chain of connected polypes, and only the last developed winged males and oviparous females might have been set free. The connecting medium might even have permitted a common current of nutriment contributed to by each individual to circulate through the whole compound body. But how little of anything essential to the animal would be affected by cutting through this hypothetical connecting and vascular integument and setting each individual free! If we perform this operation on the compound zoophyte, the detached polype may live and continue its gemmiparous reproduction. This is more certainly and constantly the result in detaching one of the monadiform individuals which assists in composing the seeming individual whole called 'Volvox globator;' and so likewise with the leaf-bud. And this liberation Nature has actually performed for us in the case of the Aphis, and she thereby plainly teaches us the true value or signification in morphology of the connecting links that remain to attach together the different gemmiparous individuals of the volvox, the zoophyte, and the plant.

The analogy between the procreating larvæ of the *Aphis*, the *Medusa*, and the *Coralline* is so true and so close, that if the larval Aphis be a distinct individual and not a part, so must be the strobila, the planula, and the gemmiparous leaf: if the succession of larval Aphides be truly described, as a succession of generations, so must that succession of planula, polype, and strobila which leads to the oviparous Medusa; and that succession of planulæ and nutritive polypes which precede the detachment of the free procreative medusiod polypes in the Coryne; and the like with the plant-generations preceding the flower.

It would have been easy, if time permitted, to multiply the illustrations of the essential condition of these phenomena. That condition is, the retention of certain of the progeny of the primary fertilized germ-cell, or in other words, of the germ-mass, unchanged

in the body of the first individual developed from that germ-mass, with so much of the pollen-force inherited by the retained germ-cells from the parent-cell or germ-vesicle as suffices to set on foot and maintain the same series of formative actions as those which constituted the individual containing them.

How the retained pollen force operates in the formation of a new germ-mass from a secondary, tertiary, or quaternary derivative germ-cell, the Lecturer did not profess to explain; neither was it known how it operates in developing the primary germ-mass.

The botanist and physiologist congratulates himself with justice when he has been able to pass from cause to cause, until he arrives at the union of the pollen-filament with the ovule as the essential condition of development—a cause ready to operate when necessary circumstances concur, and without which those circumstances would have no effect.

The chief aim of the present discourse was to point out the circumstances which bring about the presence of the same essential cause in the cases of the development of the successive generations completing the metagenetic cycle of the Aphis, the Medusa, the Polype and the Entozoon. The cause is the same in kind though not in degree, and every successive generation, or series of spontaneous fissions, of the primary germ-cell must weaken the pollen-force transmitted to such successive generations of cells.

The force is exhausted in proportion to the complexity and living powers of the organism developed from the primary germ-cell and germ-mass. It is consequently longest retained and furthest transmitted in the vegetable kingdom; the zoophytes manifest it in the next degree of force; and the power of retained germ-cells to develope a germ-mass and embryo by the remnant of the pollen-force which they inherited, is finally lost, according to present knowledge, in the class of Insecta and in the lower Mollusca.

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Among the objects exhibited in the Library, were—Edwards' Atmopyre or Gas Stove [by D. O. Edwards, Esq., M.R.I.]—Sketch of Coldham-hall, near Bury St. Edmunds, reproduced as a Photograph, coated with a solution of Gun-Cotton; and several other Photographs from Etchings &c.—and a group of Garnets in Mica Schist from the Rocky Mountains, North America [by Dr. A. S. Taylor, M.R.I.]—Specimens of Sugar of Milk [by T. N. R. Morson, Esq., M. R. I.—Model of the Nineveh Column in the British Museum, in Hall's Derbyshire black marble [by J. Tennant, Esq.] &c. &c.

# Royal Institution of Great Britain.

1851.

## WEEKLY EVENING MEETING,

Friday, February 14.

The DUKE OF NORTHUMBERLAND, President, in the Chair.

PROFESSOR EDWARD FORBES

### *On Recent Researches into the Natural History of the British Seas.*

THE Natural History of the British Seas has for a long time been a favourite subject of investigation. Within the last fifteen years, however, fresh enquiries have been set on foot, and the details of their zoology and botany worked out to an extent beyond that to which the examination of any other marine province has been carried. Numerous and beautifully illustrated monographs, treating of their fishes, cetacea, portions of the articulata, the mollusca, radiata, zoophytes, sponges, and algæ, have been published, either at private cost, or by patriotic publishers, or by the Ray Society, such as the scientific literature of no other country can show. As these have all been the results of fresh and original research, they present a mass of valuable data sufficient to form a secure basis for important generalizations.

From these materials, and from the results of the enquiries into the distribution of creatures in the depths of our seas, conducted by a committee of the British Association, a clear notion may be formed of the elements of which our submarine population is composed. Extensive tables, exhibiting the sublittoral distribution of marine invertebrata, from the South of England along the Western coasts of Great Britain to Zetland, mainly constructed from the joint observations of Professor E. Forbes and Mr. Mac Andrew, are now preparing for publication, as a first part of a general report from the Committee referred to. The data embodied in these tables are the produce of researches conducted during the last eleven years, and registered systematically at the time of observation.

British Marine animals and plants are distributed in depth (or bathymetrically) in a series of zones or regions which belt our shores from high water mark down to the greatest depths explored. The uppermost of these is the tract between tidemarks; this is the LITTORAL ZONE. Whatever be the extent of rise and fall of the tide, this zone, wherever the ground is hard or rocky, thus affording

security for the growth of marine plants and animals, presents similar features, and can be subdivided into a series of corresponding sub-regions; through all of which the common limpet (*Patella vulgata*) ranges, giving a character to the entire belt. Each of these sub-regions has its own characteristic animals and plants. Thus the highest is constantly characterised by the presence of the periwinkle *Littorina rudis,* (and on our Western shores, *Littorina neritoides,*) along with the sea-weed *Fucus canaliculatus.* The second sub-region is marked by the sea-weed *Lichina* and the common mussel (*Mytilus edulis*). In common with the third sub-region it almost always presents rocks thickly encrusted with barnacles; so that where our shores are steep, a broad white band, entirely composed of these shell-fish, may be seen when the tide is out, marking the middle space so conspicuously as to be visible from a great distance. In the third sub-region the commonest form of wrack or kelp (*Fucus articulatus*) prevails, and the large periwinkle (*Littorina littorea*) with *Purpura Capillus* are dominant and abundant. In the fourth and lowest sub-region the *Fucus* just mentioned gives way for another species, the *Fucus serratus;* and in like manner the shells are replaced by a fresh *Littorina* (*littoralis*) and peculiar *Trochi.*

Once below low-water mark the periwinkles become rare, or disappear, and the *Fuci* are replaced by the gigantic sea-weeds known popularly as tangles (species of *Laminaria, Alaria, &c.*) among which live myriads of peculiar forms of animals and lesser plants. The genus *Lacuna* among shell-fish is especially characteristic of this zone. In sandy places the *Zostera* or grass-wrack replaces the *Laminaria.* The LAMINARIAN ZONE extends to a depth of about fifteen fathoms, but in its lowest part the greater sea-weeds are comparatively few, and more usually the prevailing plant is the curious coral-like vegetable called Nullipore.

From 15 to 50 or more fathoms we find a zone prolific in peculiar forms of animal life, but from which conspicuous vegetables seem almost entirely banished. The majority of its inhabitants are predacious. Many of our larger fishes belong to this region, to which, on account of the plant-like zoophytes abounding in it, the name of CORALLINE ZONE has been applied. The majority of the rarer shell-fish of our seas have been procured from this region.

Below 50 fathoms is the REGION OF DEEP-SEA CORALS, so styled because hard and strong true corals of considerable dimensions are found in its depths. In the British seas it is to be looked for around the Zetlands and Hebrides, where many of our most curious animals, forms of Zoophytes and Echinoderms, have been drawn up from the abysses of the ocean. Its deepest recesses have not as yet been examined. Into this region we find that not a few species extend their range from the higher zones. When they do so they often change their aspect, especially so far as colour is concerned, losing brightness of hue and becoming dull-coloured or even colourless. In the lower zones it is the association of species rather than the

presence of peculiar forms which gives them a distinctive character. All recent researches, when scientifically conducted, have confirmed this classification of provinces of depth. When we have an apparent exception, as in the case of the submarine ravine off the Mull of Galloway, dredged by Captain Beechey and recorded by Mr. Thompson, in which though it is 150 fathoms deep, the fauna is that of the coralline zone, we must seek for an explanation of the anomaly by enquiring into the geological history of the area in question. In this particular instance there is every reason to believe that the ravine mentioned is of a very late date compared with the epoch of diffusion of the British Fauna.

When we trace the horizontal distribution of creatures in the British seas, we find that though our area must be mainly or almost entirely referred to one of the great European marine provinces, that to which the Lecturer has given the name of CELTIC, yet there are subdivisions within itself marked out by the presence or absence of peculiar species. The marine fauna and flora of the Channel Isles present certain differences, not numerous but not the less important, from that of the south-western shores of England, which in its turn differs from that of the Irish sea, and it again from that of the Hebrides. The Cornish and Devon sea fauna and that of the Hebrides are marked by redundancies of species; that of the Eastern coasts of England on the contrary by deficiencies. Along the whole of our western coasts, whether of Great Britain or Ireland, we find certain creatures prevailing, not present on our eastern shores. In the depths off the south coast of Ireland we find an assemblage of creatures which do not strictly belong to that province, but are identical with similar isolated assemblages on the west coast of Scotland. In the west of Ireland we find a district of shore distinguished from all other parts of our coast by the presence of a peculiar sea-urchin to find the continuation of whose range we must cross the Atlantic to Spain. In such phenomena the Lecturer sees evidences of conformations of land, of outlines of coast and connections of land with land under different climatal conditions than at present prevail within our area, for an explanation of which we must go back into the history of the geological past. If we do so, we can discover reasons for these anomalies, but not otherwise.

The dredging researches about to be published go to show that among our sublittoral animals the northern element prevails over the southern,— a fact indicated by the number of peculiar northern species; at the same time the southern forms appear to be diffusing themselves northwards more rapidly than the northern do southwards. This diffusion is mainly maintained along our western shores, and appears to be in action, not only in the British seas, but also along the shores of Norway. We must attribute it to the influence of warm currents flowing northwards, originating probably in extensions of the gulf-stream. The body of colder water in the depths of our seas preserves the original inhabitants of this area,

remnants of the fauna of the glacial epoch, overlain and surrounded by a fauna of later migration, and adapted to a higher temperature. A curious fact respecting the marine creatures of the Arctic seas of Europe, viz. that the littoral and laminarian forms are peculiarly arctic, whilst the deeper species are boreal or celtic, may be explained also by the influence of warm currents flowing northwards and diffusing the germs of species of more southern regions in the coralline and deep-sea-coral zones; for in the arctic seas the temperature of the water is higher at some depth than near the surface. On the other hand, we find in a region farther to the south than Britain, an outlier of the Celtic fauna preserved in the bays of Asturias, where it was discovered in 1849 by Mr. Mac Andrew; a very remarkable fact, and one appealed to by the Lecturer as confirmatory of his theory of an ancient coast extension between Ireland and Spain.

There is still much to be done in the investigation of the natural history of our seas, and many districts remain for more minute exploration. It is chiefly among articulate animals and especially among worms that fresh discoveries may be looked for. Yet even now new and remarkable forms of mollusca may occasionally be procured, and during the autumn of last year in a cruise with Mr Mac Andrew, no fewer than twenty additional Mollusca and Rudiata were discovered in the Hebrides, and have just been described by the Lecturer in conjunction with Professor Goodsir. Among these is one of the largest, if not the largest, compound Ascidians ever discovered. In our southernmost province fresh and valuable researches have been conducted during the past year by Professor Acland and Dr. Carus, who selecting the Scilly Isles as a field for exploration, have filled up a blank in our fauna.

The Lecturer concluded by an expression of gratification at the spread and progress of natural history studies in Great Britain among all ranks, and at the love of science manifested in the systematic manner in which our fauna and flora have been explored, and the beautiful works which have been produced in illustration of them.

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Among the objects exhibited in the Library, were — Models of Crystals, constructed of cardboard [by Rev. Mr. Mitchell] — 120 Diamond Crystals [by Jose E. Cliffe, Esq.] — an encrusted Cannon-ball found in Godwin's Sands in 1844 [by John Prosser, Esq.] — Roberts' Models of the Bow and Stern of Frigate, and of his Method of timbering the Bow [by the United Service Institution] — Fossils from the London Clay [by J. Tennant, Esq.] — a Leopard, Victoria Pigeon, and other birds, mounted by Mr. Bartlett [by the Zoological Society].

## WEEKLY EVENING MEETING,

Friday, February 21.

THE DUKE OF NORTHUMBERLAND, President, in the Chair.

W. CARPMAEL, ESQ.

### *On the Manufacture of Candles.*

FORMERLY the classes of candles manufactured in this country were Wax, Spermaceti, and Tallow, the materials being used almost in their natural state.

The manufacture of *wax* into candles has received no improvement, but is still a rude process, consisting of hanging a series of wicks (each composed of several yarns of Smyrna cotton slightly twisted together) around a hoop suspended in the air: the workman pours the melted wax on to the wicks in succession till the candles are about one-third made, when they are allowed to cool for a time: then again the process of pouring on the melted wax is repeated, till the workman judges, by sight or by weighing, that the candles are about half made; when they are again allowed to cool and set for a time, after which the candles are rolled on a slab of marble. The upper part of the candle is formed by cutting away the wax down to a metal tag, which covers one end of the wick. The candles are then again suspended to hoops, the end of the wick which had previously hung downwards being now upwards; and the process of pouring on melted wax is again repeated, and the candles finished to the desired size, when they are again submitted to the process of rolling between two smooth surfaces; the lower ends are cut off, and the candles are finished. The bees' wax employed before being thus used is bleached, and is generally mixed with a quantity of Spermaceti.

The next class of candles to which attention was called was *Spermaceti*, of which material many hundreds of tons are annually brought to this country. This material is in the manufacture of candles mixed with about three per cent of bees' wax, to prevent the spermaceti crystallizing. Formerly Spermaceti candles were inferior to those made of wax, the same class of wick being used. Some years ago platted wicks were substituted for the twisted wicks before employed: this was a great step to improvement. Platted wicks have a tendency to turn out of the flame while being consumed, the effect of which is to cause the wicks to be burned away, rendering the use of snuffers unnecessary. Since that time Spermaceti candles, in place

of being considered inferior, are preferred by many to candles made of wax. They are made by pouring the melted material into pewter moulds in which platted wicks are first inserted, and retained securely in the centre of the moulds. Other candles are also made of mixtures of wax and spermaceti, called Composition candles.

Mr. Carpmael next called attention to the manufacture of *Tallow* candles,—"dips" and "moulds." The former are made, as is generally known, by suspending several wicks a short distance apart (each consisting of several cotton yarns) on a rod; the wicks are dipped several times into melted tallow; the coats thus taken up are allowed to cool and set. The mould candles are produced by pouring the melted tallow into pewter moulds in which proper wicks (each of several cotton yarns) are first fixed centrally. These wicks require snuffing. A great improvement was some years back introduced into this manufacture by employing cords of cotton as wicks, which are coiled spirally round wires. The wires and the coiled wicks are introduced into moulds, and the wires are withdrawn when the tallow is set. These candles will, however, only burn in lamps, the turning out of the wicks melting the candles down on one side. This improvement introduced a new manufacture of lamps called Candle-lamps, which of late years have greatly increased in use; various sizes of candles being now made, some having as many as four wicks, and suitable for large table lamps. This manufacture has been greatly improved by the introduction of several means of making wicks which will turn out of the flame, and yet will admit of being introduced in a straight line within a candle. Attention was called to several descriptions of wicks for this purpose: they all act, however, on one principle, that of having a preponderance of strength on one side, which may be done in a great variety of ways. One of the most simple is the ruling of a line on one side with paste, which gives additional stiffness or strength to that one side, and such wicks in burning turn out of the flames. Following out this principle, the wicks may be modified to suit the various requirements of the different materials employed in candle-making, each of which requires a different character of wick. This was shown by several candles being burned having wicks slightly differing from those which were best for each particular case, proving that great observation and skill is requisite in the manufacturer in order to adjust the material and wick to each other in every case. Attention was also called to the fact, that up to the present time manufacturers have not been able to employ platted wicks in wax candles or tallow candles.

Ordinarily in making mould candles the wicks are placed by hand into the moulds, and the same are retained fast therein by pegs at one end and by wires at the other. A great improvement has been introduced into this part of the mechanical processes, by causing the candles as they are discharged from the moulds to draw fresh wicks into the moulds; and on the candles being then cut off from the

wicks an instrument takes hold simultaneously of all the wicks and retains them correctly in position in the several moulds.

About thirty years ago a celebrated French chemist (Chevreul), when investigating the properties of fatty matters, discovered that they consisted of certain acids; and many efforts were made to introduce one of the acids (Stearic acid) into the manufacture of candles, but with little if any practical effect, owing to its highly crystallizing properties. In order to correct this properly, recourse was had to the use of Arsenic, which was found to break up the crystals; and candles were extensively made and consumed, rivalling Spermaceti in appearance, whilst they were sold at a much less price. But public attention having been called to the injurious effects produced by the vapours of arsenic thrown off by such candles, this greatly increasing manufacture met with a severe check; and if the manufacturer had not discovered a means of employing stearic acid without arsenic in the manufacture of candles the public would probably have ceased to purchase them. This probably is one of the most interesting events in the history of the manufacture. On investigation it was discovered that the cause of the crystalline character found to prevail in stearic acid candles is consequent on the pouring very hot melted stearic acid into cold moulds; and it was found that by pouring the matter when nearly set into moulds warmed to about the same temperature as the candle-stuff, and by using a small quantity of wax, candles of stearic acid can be made possessing very excellent properties. Hence this class of candles has of late years very largely prevailed, which, being made with suitable platted wicks, like spermaceti candles, do not require to be snuffed.

Another class of candles which came largely into use about the same time was produced from the Stearine of Cocoa-nut oil; but this candle required snuffing. A great step of improvement in the manufacture of candles resulted from combining these two matters, viz. stearic acid of tallow with stearine of the cocoa-nut. It is found that stearic acid of tallow burns with a somewhat red flame and is liable to smoke; it contains too large a quantity of carbon: whilst the stearine of cocoa-nut oil contains too much hydrogen, and burns with a white flame. The effect of combining these two matters was to obtain a better flame than either, when used separately. The product is cheaper, and will also admit of the use of platted wicks; and the tendency of the stearic acid to crystallize is corrected by the employment of the stearine of the cocoa-nut. These candles are known by the name of "composite," and have been sold in immense quantities.

Mr. Carpmael next called attention to the modern introduction of Palm-oil in the manufacture of candles, the properties of which are peculiarly suited to candle-making. The *stearine* of it, even in its crude state makes excellent "dip" candles when the quality of the light only is considered; but they are of a bad colour: the palm

stearine also makes good lamp-candles: but the great use of Palm-oil as a candle-stuff is when distilled for this purpose. The crude oil is first treated with acid to bring it into an acid state, and the same is then distilled by means of steam, which in its passage from the boiler passes through a series of pipes heated by a furnace, by which the steam becomes very highly heated (600° Faht.) and in that state it enters into the still, and amongst and below the chemically prepared palm-oil, which is thereby caused to distil over, and is condensed in suitable apparatus; the product is preserved: and by these means a most beautiful material closely resembling spermaceti is obtained, and from which those modern manufacture of candles now so largely and so well known as Belmont sperm and Belmont wax are produced.

The table was largely supplied with candles of every description of manufacture, by which the peculiarities of each class could be readily pointed out, and examined.

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In the Library were exhibited:—Views of Alpine Passes [by George Barnard, Esq.]—Ancient Greek Lamps [by the United Service Institution]—Mr. Thomson's Letter Copier [by Mr. Thompson,]—And from the Royal Institution Museum, Models of a Mode of raising stones for building (suggested by Mr. Perigal to have been employed in constructing the Pyramids); Candles employed by Colliers before the invention of the Safety Lamp; Model showing circulation of fluids; Minerals, Animal Concretions, &c.

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## WEEKLY EVENING MEETING,

Friday, February 28.

The Duke of Northumberland, President, in the Chair.

Professor Cowper,

*On Lighthouses.*

The difficulties so successfully surmounted in the construction of the Eddystone, the Bell Rock, and the Skerrevore Lighthouses, and the philosophy of their brilliant light, renders them eminent objects of that scientific interest which belongs to all similar structures.

The Eddystone Lighthouse, having been built of wood in 1698, was carried away five years after its erection. It was shortly afterwards reconstructed of the same material, the lower part being filled with stone or concrete; it then lasted for forty years, when it was consumed by fire. In 1759 Smeaton completed the present lighthouse, which is

68 feet high, and the base 26 feet in diameter, (being barely less than the surface of the rock on which it stands). It is built of stone; the stones are dovetailed together, and "joggled" as it is termed, so as to prevent the courses of stones from sliding on each other. It is situated in the midst of the sea, nine or ten miles distant from Plymouth.

The Bell-rock Lighthouse stands on a rock of the same name on the east coast of Scotland. It is surrounded by the sea, and is 100 feet high, and 42 feet in diameter at the base. It was built by Robert Stevenson, and finished in 1810. Its construction is similar to that of the Eddystone.

The Skerrevore Lighthouse was built by Alan Stevenson, son of the architect of the Bell Rock Lighthouse. The mass of stone in this structure is more than double that used in the Bell Rock, and five times that contained in the Eddystone. The tower is 138 feet high, and the diameter at the base is 42 feet. It stands on a gneiss rock, the area of which is just large enough for the foundation. In constructing this lighthouse, the architect appears to have chiefly relied on the weight, rather than on the extension of the materials, for efficient resistance to the impact of the waves. The stones were not dovetailed or joggled, but tree-nails were used merely to keep the work together during its erection.

Several lighthouses have of late years been constructed of *cast iron*. One designed by Mr. Alexander Gordon, and made by Messrs. Cottam and Hallen, has been erected at Bermuda; it is 130 feet high.

Messrs Walker and Burgess have recently constructed efficient lighthouses on iron piles, which are fixed in the sand by means of a screw, invented by Mitchel. The Maplin and Chapman lights, at the mouth of the Thames, and those at Fleetwood and Belfast, are on this principle. Professor Cowper invited attention to the mode in which these structures are rendered compact by means of cast-iron braces.

The *Sources of Light* and mode of diffusing it were next adverted to.

Common fires, first of wood, and then of coals, were originally used to furnish light. A coal fire was employed for this purpose in the Isle of May for 180 years (as late as the year 1816). Tallow candles succeeded;—candles fastened on wooden rods (as they are sometimes seen arranged before booths in fairs,) were burnt in the Eddystone Lighthouse for 40 years after it was completed by Smeaton. Then came lamps with twisted-cotton wicks, and then common Argand lamps: all these however are now superseded by—(A.) *Argand lamps and reflectors;* (B) *one Argand lamp, with lenses and reflecting mirrors; and* (C) *one Argand lamp with lenses and reflecting prisms.*

Mr. Cowper here illustrated the laws of reflection by several models, diagrams, and familiar examples. As instances of refraction, he alluded to the line of light produced on rippling water by the

rays of the sun or moon; each wave may (in common with every curved surface) be considered as a polygon having an infinite number of sides: there must therefore be some side in such a position as will reflect the light. The same effect was produced by a row of glass rods placed side by side; reference was also made to a looking-glass casting the sunshine on the wall,—to reflectors placed at a window to exhibit objects in the street,—to the glow in the sky produced by a burning house; this appearance being half-way between the spectator and the conflagration, occasions continual mistake as to the locality of the fire.

A. *Argand lamps and reflectors.*—Having exemplified the principle upon which light is reflected, Mr. Cowper demonstrated, by means of a series of small mirrors which were moveable on a fixed axis, that if a light were placed in the focus of a paraboloid, the rays would be reflected parallel. This is done in those lighthouses where reflectors are employed.—The difficulty of shaping paraboloids was referred to, and it was mentioned that they were raised from a flat sheet of metal by the hammer. The arrangement of the lamp and reflector was described; and the halo-like diffusion of the light, consequent on the impossibility of concentrating the luminous point in the focus of the parabola, was noticed.

In connexion with this part of his subject, Mr. Cowper, dwelt on the distinction between a *fixed* and a *revolving light*. The former, being intended to be visible all round the horizon, requires more lamps than the latter; when three rows of twelve lamps, each row being in contact, are arranged in a circular form, the three lamps which are in a vertical line immediately opposite to the spectator, afford a strong light, while the three on either side are less distinctly seen, the parallel rays described not reaching his eye.

With respect to the *revolving lights*,—supposing 28 lamps arranged on the four sides of a parallelopipedon; then, as the figure revolves, each side will present seven lamps in succession. These, by shining at once, will produce a much stronger light than the fixed light. The duration of this effect will, however, be short; because, as each side is turned away from the spectator, the light will decrease rapidly; this will be succeeded by darkness, and this darkness will in its turn be dispersed by a rapidly increasing light.

Mr. Cowper proceeded to state that so satisfactory had been the result of metal reflectors in lighthouses, that there seemed small scope for improvement, until Fresnel devised the application of lenses, and also reflecting prisms in combination with lenses, to a single large lamp.

To make this invention clearly understood, Mr. Cowper explained the general laws of the reflection of light, and illustrated his explanations by various diagrams and models.

B. *One Argand lamp, lenses, and reflecting mirrors.*—Having shown that light on passing through a triangular prism of glass is refracted towards its base, Mr. Cowper applied this principle to the con-

struction of a lens which he derived from two long thin prisms placed base to base. He demonstrated that diverging rays of light, admitted on one side of such a solid, would issue parallel on the other side.

There are great practical difficulties in fabricating a large glass lens. Condorcet and Brewster suggested, and Fresnel effected, the construction of a lens of separate prisms, all unnecessary glass being removed. Diagrams of such lenses were shown; and it was stated that they were used with a single large lamp placed in the focus of the lens. In this position, however, as was shown, all the rays which passed above and beneath the lens might escape. To intercept the rays Fresnel placed silvered glass mirrors at the proper angles.

Fresnel also made a polygon of straight lenticular prisms producing a long line of strong light: but the greatest improvement effected by this great philosopher was the substitution of *reflecting prisms* for mirrors, thus introducing—

C. *The principle of lighting by one Argand lamp, lenses, and reflecting prisms.*—Mr. Cowper here demonstrated, by an apparatus contrived for the purpose, that when light is incident on the second surface of a prism, it may fall so obliquely that the surface cannot refract it, and that therefore this incident light is *totally reflected* from the second surface. Thus, if a ray enters the glass prism so as to make the angle of incidence greater than 41° 49′ it is totally reflected.

Mr. Cowper showed how this principle is applied in lighthouses. He stated that the first light of this kind, on a large scale, was put up by Alan Stevenson at the Skerrevore; and that, in 1843 Fresnel tried its illuminating powers against those of mirrors, and found the superiority to be in proportion of 140 to 87.

"On this subject," said Mr. Cowper in conclusion, "one is "struck with the intensity and exclusiveness of thought devoted to "each part of the whole matter. The Admiralty intensely desire a "lighthouse on a particular spot. The Engineer is intensely "occupied in surveying, levelling, and building; and with a per"severance almost superhuman, he continues his work during two or "three years on the edge of a rock just showing itself above the "waves. He makes a temporary barrack on wooden piles on some "adjacent point. This is all swept away in one night. He builds "it again, and is obliged to live in it for fourteen days together, the "weather preventing all access to it. Presently, however, a tower "138 ft. high stands securely fixed on the exact spot assigned to it. "But the Philosopher has also been at work, quietly but intensely "considering the laws of reflection and refraction, and has contrived a "glass prism of a new form, — without a thought of standing knee"deep in water twelve miles from land. The glass prisms and lamp "are now mounted on the tower, and confided to the keepers. These "men have no careless task. If they have many lamps, as in a

"revolving light, the going out of one is comparatively immaterial; but when one light only is used, life and death hang on its burning. Their intensity of thought is to keep it lighted.—In the ship that is approaching are two small instruments, the quadrant and the chronometer (the products of science); with these the Captain will ascertain his position on the trackless ocean. He probably regards neither the construction of the lighthouse nor its beautiful light. His intense interest is to *see* it.— He says, 'If I have calculated rightly by my instruments, and made allowance for the convexity of the earth, at such an hour the light will come into view.' Judge of his delight when it meets his eye! It is as if his country watched for his return, and welcomed him home."

[*** For further information the Members are referred to Mr. Alan Stevenson's Rudimentary Treatise on the History, Construction, and Illumination of Lighthouses, illustrated by plates and diagrams, published by Mr. Weale, 59, High Holborn.]

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In the Library, were exhibited: —

Model of Lantern of Eddystone Lighthouse [by Mr. Wilkins,] and Smeaton's Account of the Eddystone Lighthouse [from the Royal Institution Library].

Fishes from the Mediterranean, preserved by Capt. Graves, R.N., and the Officers of the Mediterranean Survey [by Professor E. Forbes].

Photographs, principally taken in Paris, by Sir W. J. Newton [by Rev. J. Barlow, Sec. R. I.].

Models of Revolving lights for Steamers, of Tide Indicator at Ramsgate, and of Pratt's Pier for Tidal Rivers [from the Society of Arts].

Model of a 46-gun Frigate with Roberts's Circular Bow, a Danish Signal Lantern &c. [from the United Service Institution].

Mr. Faraday exhibited a Magnet, made by Hæcker of Nuremberg, weighing 36 grains, capable of supporting 5280 grains, being *one hundred and forty six times* its own weight.

It will be remembered that the expression of force deduced by M. Hæcker from the examination of a great number of magnets is $p = 10\, n^{\frac{2}{3}}$.

## GENERAL MONTHLY MEETING,

Monday, March 3.

WILLIAM POLE, ESQ., F.R.S., Treasurer and Vice-President, in the Chair.

Benjamin Gibbons, Esq.
Edward H. Keeling, Esq.
Adam Murray, Jun. Esq.
James Scott, Esq.

were *admitted* Members of the Royal Institution.

Francis Bayley, Esq.
John J. Bigsby, M.D.F.G.S. &c.
William F. Cowell, Esq.
Edward Dumergue, Esq.
William Henry Fisher, Esq.
Fred. Solly Flood, Esq.
Rev. Joseph Hambleton, B. D.
Lady Herschel.
Edwin Lankester, M.D. F.R.S.
The Lord Moreton.
William Morgan, Esq.
Henry Twining, Esq.
Athelstane Willcock, Esq.
James S. Willes, Esq.

were duly *elected* Members of the Royal Institution.

The Vacancy in the Fullerian Professorship of Physiology was announced, and the Members were informed, that, in pursuance of the Trust Deed, a Professor would be elected by the Managers on the 8th of July, 1851, at 4 o'clock, P.M.

The Secretary reported that the following Courses of Lectures would be delivered after Easter, viz.

Six Lectures on some Points of Electrical Philosophy — by Professor FARADAY.

Seven Lectures on Cosmical Philosophy — by Rev. Professor BADEN POWELL, of Oxford.

Seven Lectures on Manufactures and Construction — by Professor EDWARD COWPER, of King's College, London.

The following PRESENTS were announced, and the thanks of the Members ordered to be returned for the same :—

FROM

*Dr. G. A. Mantell (the Author)*— On the Remains of Man and Works of Art imbedded in Rocks and Strata. 8vo. 1850.

*M. Faraday, Esq. Full. Prof. Chem. R. I.* — Abhandlungen der Königlichen Akademie zu Berlin, 1840 — 1848. 11 vols. 4to.

Monatsberichte derselben. Jan.—April, 1836. Jan.—Dec. 1850. 8vo.

Bulletins de la Classe Physico-Mathématique de l'Académie Impériale des Sciences de St. Pétersbourg. Tome IX. No. 1 — 6. 4to.

*The Geological Society.* — Quarterly Journal, Vol. VII. No. 25. 8vo. 1851.

*The Franklin Institute.* —Journal, Vol. XIX. 3rd Series. 1850.

*The Zoological Society.*—Transactions, Vol. IV. Part I. 4to. 1850.
*Sir J. W. Lubbock (the Author).*—On the Gnomonic Projection of the Sphere. 8vo. 1851.
*The Duke of Northumberland, Pres. R. I.*—Report of Select Committee on the British Museum. fol. 1836.
Report on Accidents in Coal Mines. fol. 1849.
Report on the Ventilation of Mines in Collieries; by J. Phillips, Esq., F.R.S. fol. 1850.
Report on the Application of Iron to Railway Structures, with Plans. fol. 1849.
Report on the Selection of Stone for the New Houses of Parliament. fol. 1839.
Report on Smithfield Market. fol. 1850.
First Report of Metropolitan Sanitary Commission. fol. 1847.
*John Prosser, Esq. Life-Sub. R. I.*—An Historical and Geographical Description of Formosa, by George Psalmanazar. 8vo. 1704.
The Anti-Jacobin, or Weekly Examiner [Edited by W. Gifford.] 2 vol. 8vo. 1799.
*The Royal Institute of British Architects*—Proceedings for Feb. 1851. 4to.
*The Institution of Civil Engineers*—Proceedings for Feb. 1851. 8vo.
*The Duke of Somerset, M.R.I. (the Author)*—A Treatise in which the Elementary Properties of the Ellipse are deduced from the Properties of the Circle, and Geometrically demonstrated. 2nd Edition. 12mo. 1843.
Alternate Circles and their Connexion with the Ellipse. 12mo. 1850.
*Her Majesty's Government*—Observations on Days of Unusual Magnetic Disturbance, made at the British Colonial Magnetic Observatories; printed under the superintendence of Lieut.-Col. Edw. Sabine. Vol. I. Part 2. 4to. 1851.
*Col. Philip J. Yorke, F.R.S. M.R.I.*—Tableau Orographique de la Chaine des Pyrénées, composé par Emilien Froissard. (On a sheet.) 1849.
*The Asiatic Society of Bengal*—Journal, No. 214. 8vo. 1850.
*The Linnean Society*—Proceedings, 1849-50, No. 41—43. 8vo.
List of Fellows. 1850.
*The Royal Medical and Chirurgical Society*—Index to Medico-Chirurgical Transactions, Vol. I. to XXXIII. 8vo. 1851.

*C. D. Archibald, Esq., M.R.I.*—Specimens of Oxide of Manganese.
*Wm. Pole, Esq. Treasurer R. I.*—Specimens of Crystals (Hydrolite or Gmelinite) in Amygdaloid Rock.
*W. R. Hamilton, Esq., M.R.I.*—Piece of Fossil Rock from Cerigo.
*Sir Roderick I. Murchison, M.R.I.*—Portrait of Sir R. I. Murchison, engraved by W. Walker. 1851.

[FOR THE USE OF MEMBERS.]

# Royal Institution of Great Britain.

1851.

## WEEKLY EVENING MEETING,

Friday, March 7.

THE DUKE OF NORTHUMBERLAND, President, in the Chair.

SIR RODERICK IMPEY MURCHISON, V.P.R.S.

*On the former Changes of the Alps.*

THE complicated structure of the Alps so baffled the penetration of De Saussure, that after a life of toil the first great historian of those mountains declared "there was nothing constant in them except their variety." In citing this opinion, Sir Roderick explained how the obscurity had been gradually cleared away by the application of modern geology, as based upon the succession of organic remains, and then proceeded to indicate the accumulations of which the Alps were composed, and the changes or revolutions they had undergone, between the truly primæval days when the earliest recognizable animals were created, and the first glacial period in the history of the planet.

The object being to convey in a popular manner clear ideas of the physical condition of these mountains at different periods, three long scene-paintings, prepared for the occasion, represented a portion of the chain at three distinct epochs. The first of these views of ancient nature exhibited the Alps as a long, low archipelago of islands, formed in great part out of the Silurian and older sediments which had been raised above the sea, when the lands bore the tropical vegetation of the carboniferous era.

Stating that there were no relics in the Alps of the formations to which he had assigned the name of Permian, as marking the close of the primæval or palæozoic age, Sir Roderick rapidly reviewed the facts gathered together by many geologists from all quarters of the globe, and maintained that they unequivocally sustained the belief, that there had been a succession of creations from lower to higher types of life, in ascending from inferior to superior formations. He carefully, however, noted the clear distinction between such a creed, as founded on the true records of creation, and the theory of transmutation of species; a doctrine put forth in the popular work entitled the "Vestiges of Creation," and from which he entirely dissented.

In the second painting (an immense lapse of time having occurred)

the Alps were represented as a mountainous ridge in which all the submarine formations, from the mediæval up to the older tertiary or Eocene, had been lifted up upon the flank of the primæval rocks. Each rock system being distinguished by a colour peculiar to it, the nature of the animals contained in each of these deposits was succinctly touched upon. Between the youngest of the primæval formations and the oldest of the mediæval or secondary rocks, it was stated, that there is not one species in common to the two in any part of Europe; the expression being that "an entirely new creation had succeeded to universal decay and death."

In speaking of the Alpine equivalents of the British Lias and Oolites, Sir R. paid a deep-felt tribute to Dr. Buckland, who thirty years ago had led the way in recognizing this parallel; and Leopold von Buch was particularly alluded to as having established these and other comparisons, and as having shown the extent to which large portions of these mountains have been metamorphosed from an earthy into a crystalline state. In treating of the cretaceous system it was shown that the Lower Green Sand of England, so well and so long ago illustrated by Dr. Fitton, was represented in the Alps by large masses of limestone, since called Neocomian by foreign geologists.

Emphasis was laid upon the remarkable phenomena, that every where in the south of Europe (as in the Alps) the Nummulite rocks, with the 'flysch' of the Swiss, and the 'macigno' of the Italians, have been raised up into mountains together with the Hippurite and Inocerami rocks, or the chalk on which they rest; and hence it was, that before Sir R. made his last survey of the Alps, the greater number of geologists classed the Nummulite rocks with the cretaceous system, and considered them both to be of mediæval or secondary age. But judging from the fossils which differ entirely from those of the chalk (except at the beds of junction) and also from their super-position, he had referred these Nummulite rocks to the true lower tertiary or Eocene of Lyell. Beds of this age, though once merely dark-coloured mud, have been converted into the hard slates of Glarus with their fossil fishes (among which eels and herrings first made their appearance); other strata of this date contain the well known fishes of Monte Bolea; and others again have been rendered so crystalline amid the peaks of the Alps as to resemble primary rocks, so intense have been the metamorphoses!

Dwelling for a few minutes on the atmospheric conditions which prevailed after the elevation of the older tertiary, Sir R. inferred that a Mediterranean and genial climate prevailed during all the long period whilst the beds of sand (Molasse) and of pebbles (Nagelflue) were accumulating under the waters both of lakes and of the sea, and when derived from the slopes of all the pre-existing rocks. The marine portions of the Molasse and Nagelflue contain the remains of many species of shells now living in the Mediterranean; whilst in alternating and overlying strata, charged exclusively with land and fresh water animals, not one species among many hun-

dreds, including numerous insects, is identical with any form now living. This point, on which he first insisted on his return from the Alps in 1848, Sir R. had considered to be of paramount importance in proving, that terrestrial life was much less endowed with the capacity to resist physical changes of the surface than submarine life; for here we have a fauna which is Pliocene in the order of the strata, and yet is not Eocene in its animal and vegetable contents.

A certain number of the more remarkable animals that lived during this younger tertiary age were then adverted to, such as the Rhinoceros and other large quadrupeds, the fossil Viverrine fox (the original of which was on the table), the huge Salamander (Andrias Scheuchzeri) and a Chelydra which had been described as analogous to the snapping turtle of the southern states of North America. These, with quantities of plants, including small palms, were all indicatives of a warm and genial climate; and on such sure grounds the second diagram placed the Alps before the spectators as covered with a suitable vegetation, and with several of the abovementioned animals in the foreground.

Having satisfied himself, in common with M. Studer, M. Escher, and all the geologists who have well explored the Alps, that every where along their northern flank a terrific dislocation has occurred, amounting in many places to a total inversion of mountains, between the older Tertiary and those younger deposits which were accumulated under the waters during the period he had just been describing, Sir Roderick then briefly pointed out that he had demonstrated in detail elsewhere: viz. that the sands and pebble-beds of that age had been suddenly heaved up from beneath the waters all along the outer or northern flank of the chain, so as to form mountainous masses, the inverted and truncated ends of which had been forced under the edges of the very rocks out of whose detritus they had been formed.

Before this great revolution had taken place no large erratic blocks were known, but after it they became common, and were the necessary production of that intensely cold climate to which the Alps were then subjected; a change of which their surface bears distinct evidence.

During the same period the low countries of northern Europe were covered by an Arctic sea. If such waters then extended to the Jura and the Alps, icebergs and rafts must have been detached from the latter, carrying away blocks of stone northwards, to be dropped at intervals, just as it has been demonstrated that the Scandinavian blocks were dropped in Prussia, Poland, and the low lands of Russia, when all those regions were under the influence of an Arctic sea. Bavaria, and the lower parts of the Cantons Vaud, Neufchatel, and Berne, were, it is supposed, then covered by waters which bathed the foot of the Alps.

That the change from a former genial climate to the first great

period of cold was a sudden one is further sustained by the fact, that the inclined strata in which the Mediterranean animals are buried, are at once covered *transgressively* and *unconformably* by other beds of gravel, shingle, and mud, in which the remains of plants and animals are those of a cold climate.

The third scene, therefore, exhibited the sands and pebbles of the genial period thrown up into mountains on the flanks of the chain, the peaks of which were probably covered for the first time with snow, and from the openings of which, whether protruding to the sea-shore or into deep fiords or bays, glaciers and their moraines advanced, from which ice-bergs or rafts were floated away as suggested.

In concluding Sir Roderick thus expressed himself: — "Having "thus now conducted you rapidly through the most prominent "changes which the Alps have undergone, from the first period when "they had emerged, probably as an archipelago of low islands in a "tropical climate, to that epoch when the animals and plants living "upon them indicated a Mediterranean temperature, and then to that "Arctic period, the conditions of which I have just been discussing, "I have no longer to call for your assent to any inferences of "the geologist, which all of you are not perfectly competent to un- "derstand.

"To convert the Alps of the earliest glacial period into the Alps "of the present day, you have only to figure them to yourselves, as "raised 2000 or 3000 feet above the altitude which they are sup- "posed to have in the diagram last exhibited. All their main "features remaining the same, you would then have before you, the "present Alps and their valleys, irrigated by lakes and rivers instead "of bays; and in place of the waters sketched in beyond them as "in the painting, with ice-bergs floating upon them, you will then "have dry mounds of gravel, sand, and blocks, which were accumu- "lated under the former waters; such, in a word, as now constitute "low hills and valleys and all the richest land of Switzerland and "Bavaria, where man has replaced the rhinoceros and turtles of one "period, and the icebergs of another. You who have not visited "this noble chain, and who wish to judge of its gorges, peaks, and "precipices have only to consult the views of our associate Brocke- "don, in order to have nature in her present mood, brought in the "most telling manner before you. But those of you who really "wish to grapple with the geological wonders of former days, may "look at the flanks of the Rigi from the lake of Lucerne, whence, "even from the deck of the rapidly passing steamer, you will see "how that great pile of pudding-stone, every pebble of which "has been derived from rocks in the chain more ancient than itself, "has been lifted up from beneath the waters in the manner re- "presented; whilst if you continue the same traverse up the Lake to "Altorf, you will pass by numerous extraordinary folds and breaks of "the secondary limestones, and of the older Tertiary or Nummulitic

"rocks. Such a doubling or crumpling up of these strata, you may "then perchance agree with me in thinking, was in a great measure "the result of lateral pressure between two great masses; the crys- "talline centre of the chain upon the South, and the newly upraised "deposits on the North, of which the Rigi is a small part only, which "latter having been intruded upon the terrestrial surface, necessarily "compressed the pre-existing formations into a smaller compass. "If more adventurous, you should climb to peaks rising to 8000 or "9000 feet above the sea, that flank the central summits, you may "there satisfy yourself, that deposits, which were once mere mud, "formed during the same time as our slightly consolidated London "Clay, have been in many parts converted into schists and slates as "crystalline as many of the so-called primary rocks of our islands. "So intense has been the metamorphosis!

"In speaking of the last changes of the Alps as stupendous, I "know it may be said that, in reference to the diameter of the planet, "the highest of these mountains and the deepest of these valleys are "scarcely perceptible corrugations of the rind of the earth. But "when we compare such asperities with all other external features of "this rind, they *are* truly stupendous. How, for example, can the "observer travel over vast surfaces such as Russia, and not be able "there to detect a single disruption — not one great fracture, and "no outbursts whatever of igneous and volcanic rocks; but, on the "contrary, a monotonous and horizontal sequence of former aqueous "deposits, which, simply dried up, have never been disturbed by any "violent revolutions from beneath, and then compare them with the "adjacent Ural mountains, or still better with the loftier Alps, and "not be impressed with the grandeur of such changes?

"And here my auditors will recollect, that even beneath and "around this metropolis they can be assured by finding extinct "fossil mammalia, that such also have been the changes, though on "a less scale, in our own country. The large extinct British "quadrupeds necessarily required a great range for their sustenance. "They had doubtlessly roamed from distant tracts to our lands "before the straits of Dover were formed and before the British "dominions were broken into isles. Our great insular dislocations "were, I conceive, coincident with that striking phenomenon in the "Alps on which I have tried to rivet your attention, when the first "glacial and icy period affected so large a portion of this hemisphere, "and when large portions of our northern lands formed the bot- "toms of an Arctic sea. But such tracts were bidden to rise again "from beneath the waters and constitute the present continents "and islands before man was placed on the surface. Our race, in "short, was not created until the greater revolutions of which "I have treated had passed away.

"These grand dislocations belong, therefore, distinctly to former "epochs of nature, and their magnitude *is* enormous when compared "with any thing which passes under our eyes, or has been recorded

"in human history. At the same time geologists have shown upon "clear evidences, that during the long and comparatively tranquil "former period which intermitted with geological revolutions, there "was a constant exhibition of diurnal agencies similar to those which "prevail in the present world. In those older times, rain must have "fallen as now, — volcanic forces must have been active in scattering "ashes far and wide, and in spreading them out together with sheets "of lava beneath the waters, — gradual movements of oscillation "and moderate elevations and depressions must have occurred, — long "continued abrasion of the sides of mountains must have produced "copious accumulations of 'débris' to encroach upon lakes, the "overflow or bursting of which may have sterilized whole tracts.

"All such and many more modifications of the ancient surfaces of "the globe, including many slight breaks in the long career, were "doubtlessly common to all epochs. But whilst no such operations "can be compared with those phenomena of disruption and over-"turning of mountain masses which have been specially dwelt upon "this evening, so also according to my view it is impossible, that any "amount of small agencies, if continued for millions of years, could "have produced such results.

"In thus attempting to shadow out in the space of an hour all the "chief formations and transmutations of a chain like the Alps, I have "probably laboured to effect what many persons may deem impossi-"ble; but I have thought that some at least of these evening dis-"courses should awaken the mind to the larger features of each "science, the details of which must be followed out in courses of "lectures. I would beg, therefore, those persons who have not "studied geology practically, to dwell chiefly on the facts brought "forward, and to believe that they are indisputably and clearly "proven. They tell us unmistakeably how different creations of "animal and vegetable life are entombed in these vast monuments "of ancient nature, and they reveal to us that each creation of the "successive inhabitants of the surface lived during very long periods "of time. They announce to us, in emphatic language, how "ordinary operations of accumulation were continued tranquilly "during very lengthened epochs, and how such tranquillity was "broken in upon by great convulsions.

"Being thus led to ponder upon the long history of successive races "and also upon some of the most wonderful physical revolutions the "chain has undergone, we cannot avoid arriving at the belief, that, "in addition to many other great operations, the disruption which "upheaved the middle and younger Tertiary formations from beneath "the waters, and threw them up into mountain masses accompanying "the production of the first great arctic period known in the history "of the planet, was a change of inmeasurable intensity. That change, "in short, by which a period of snow, ice, glaciers, floating ice-bergs, "and the transport of huge erratics far from the sources of their "origin, suddenly followed a genial and Mediterranean clime!"

R. I. M.

In the Library, were exhibited :—

A Series of Original Views of the Alps by W. Brockedon, Esq.
Talbotypes taken in Italy by E. Kater, Esq., M. R. I.
Specimens and drawings of the Caddis-worm, by Mr. T. L. Shuckard.
Centrifugal Pump, by Mr. Appold.
Fish from the Lias, Barrow-on-Sour [by Mr. Tennant] ; &c. &c.

A horseshoe magnet, made by M. Logeman of Haarlem according to the instructions of M. Elias, was placed on the table by Mr. Faraday. Its weight was 0·98 of a pound and it could carry above 27 lbs. In the expression of the force of a horseshoe magnet deduced by M. Hæcker (p. 28), the power of a magnet of $n$ kilogrammes weight is $10{\cdot}33\, n^{\frac{2}{3}}$; in the present case the co-efficient, instead of being 10·33, is double that amount.

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## WEEKLY EVENING MEETING,

Friday, March 14.

Sir Charles Fellows, V. P. in the Chair.

Dr. Gull,

*On some points in the Physiology of Voluntary Movement.*

The Lecturer began with some observations upon the distinctions which exist between voluntary movements and the phenomena of motion in dead or inorganic masses. In voluntary movement the stimulus is *within* and independent, the elements which are brought into play are numerous and complex, and the result is the fulfilment of a purpose designed by the individual.

On the contrary inorganic movements are due to an impulse from *without:* the motion is more general, and does not fulfil any direct design.

In the constitution of animals, besides those which are voluntary, there exists the mechanism for a number of subordinate movements, which, although they do not present a complete gradation to the inorganic forms of motor force, yet follow directly from the physical structure of the body, and are altogether independent of the consciousness and will of the individual.

The object of the Lecturer was to show the relation of voluntary movements to this substratum of natural actions.

In order to elucidate the subject, attention was first drawn to the vertebrate skeleton for swimming, flying, burrowing, leaping, running, and walking, and to the purpose which governs these modifications ;

namely, variety of voluntary movement according to the particular requirements of each animal.

Man, by his adaptation to the erect position, presents the highest illustration of this vertebrate intention. His anterior extremities, not being employed in locomotion, are left free to become the ministers of more subtle volitions, to which they are well fitted by the unfettered condition of their parts, and by their capability of forming an almost infinite variety of combinations.

On reviewing the extent and kind of movement enjoyed by the different members of the animal kingdom, it seems probable, that in many of the lower forms, the phenomena are of an entirely physical nature, and that voluntary power is not manifested until we have a corresponding developement of the senses.

The expression "Corpus animale machina muscularis" is rightly applied to that apparatus of bones, muscles, nerves, and *myelon** which is arranged for our use and subordinated to our will. Nor is there anything contradictory to freedom in the admission of a pre-arranged mechanism to minister to voluntary action. The law of limitation is expressed in the anatomical structure of the parts. In the lower animals this is very obvious:— for instance, although the bird has the power of employing its wing at will, yet in the wing itself there is limitation to certain kinds of movement, namely, to folding or extending it, but there is no freedom for other motions. What is true of the coarser parts seems to apply to the more delicate arrangements in the nervous structure, although they are too delicate for our present means of unravelling and displaying them, and we are left to read their anatomy by the physiological phenomena they present.

The characters of the myelon which entitle it to be considered an independent element of the nervous system were brought under notice. Its developement at different parts bears a proportion to the corresponding segments of the skeleton. In illustration, its uniform size in the viper, and the cervical and lumbar enlargements in the bird, as also the mode in which the nerves are connected with it, were demonstrated. The anatomy of a plexus seems to give us a striking proof of myelonic origin of nerves, as opposed to the theory which admits of their direct continuity upwards through the myelon to the brain. When the motions of the segments of the skeleton are simple, as occurs throughout the whole length of the body in the viper, and in the cervical and dorsal regions in the bird, the nerves arise by *single roots;* but where the nervous supply is to parts complicated in their structure and adapted for varied movements, the nerves arise by *many roots.* Thus if we divide the nerves of the brachial plexus of the bird into four sets, one for folding the wing, one for unfolding it, one to go to the strong muscles of the shoulder, and one to the

* This term is used as first proposed by Professor Owen, to designate the series of nervous centres commonly called *Spinal Chord.*

scapular muscles, we find that each of these sections is connected by four distinct roots with the common myelonic centre.

In man five segments enter into the formation of the enlargement from which the nerves of the brachial plexus are derived, and the different sets above enumerated may be shown to have connexions for the most part with the whole of them, or at least with four out of five. For instance, the nerve which supplies the muscles for extending the arm and the fingers (radio-spiral), if traced to the myelon, will be found to divide into *five roots*, and the same may be said of the nerves belonging to the other sets. These facts can scarcely admit of any other explanation than that here given, namely, myelonic origin.

The independent mechanism of this system was illustrated by reference to the ordinary functions of breathing, swallowing, the motions of decapitated animals, and some morbid states.

The supposed existence of two systems in the body for motion, — one mechanical, having its roots in the myelon, and the other volitional, having its roots in the brain, — was considered inadmissible.

There is probably but one system, namely the myelonic, which is subordinated in different degrees to the encephalon (brain), according to the purposes it is intended to subserve. Those parts of it which are in communication with the nerves supplying the extremities, are completely subordinated. Others, as for instance those which give origin to the nerves of respiration and deglutition, only partially so; by this subordination, animals have the power of producing their various volitional movements through the instrumentality of a system whose power is in itself, but under the restraint and direction of the will.

On considering the steps of the process by which we use this mechanism, it will be readily admitted, that *subjectively*, we have little or no influence. Thus, however well we may be acquainted with the structure and position of the muscles and nerves of our arms, we cannot excite *directly* any one of them we may desire to select. Such power, if we possessed it, would be altogether useless, inasmuch as by far the largest number of men, and all animals, must ever remain ignorant of their own structure. On the other hand an *objective intention* instantly calls forth the means necessary to produce the desired result. As by the principles of common sense (using this expression as Reid used it) we refer sensations to the objects producing them, so in the use of our muscular machine we have no other guide or power than this *objective* one, which our proper constitution supplies.

The relation of external impressions to resultant movements is therefore of particular interest. It has been already stated, that some animal movements are merely physical (auto-myelonic) excited by external impressions and unattended by any consciousness. Next to these and in close alliance with them are movements also following directly from an external impression, which although it be felt, still

the movement is spontaneous and not willed. For instance, a ray of light falling on the sensitive surface at the bottom of the eye (retina) produces a contraction of the pupil, a movement of which we are entirely unconscious. Irritation of the lining of the nostril is followed by an irresistible tendency to motion for removing it (sneezing). In a still higher series, we have the mechanism brought out by conditions more complex than mere sensations. The emotions, anger, joy, sorrow, though based upon the psychical constitution, yet have a mechanical expression independent of the will; the contraction of the muscles of the face varying precisely according to the kind and degree of the emotion, and thus forming a language which we instantly read, a language which is unchangeable and universal, and without compact or imitation.

From this substratum of natural actions, we pass to such as are voluntary, over which we feel we have power. These, as we have previously seen, are also related to external impressions. It has been stated that the elements of the motor mechanism are not directly submitted to the will, and that we require an objective impression or an objective design to guide us. If the objective impressions are confused, our volitional power is for the time disturbed; hence the unsteadiness which follows upon looking at a moving object, as a railway carriage in rapid motion, when we are so near to it that it excludes objects at rest; hence also much of the unsteadiness which follows upon ordinary giddiness. The office of sensation as a guide to our voluntary movements and as *suggestive* of them is also well illustrated in the teaching of deaf-mutes. The muscular system of the organs of voice in these persons readily obeys the stimulus of physical or emotional impulses, for they cry and shout; but it lies unused as an instrument of volition, until through the suggestion of the sense of touch its vibrations are excited, afterwards to be vocalized into speech by the imitative teaching of the eye. Although by the aid of these two senses mutes may be taught to use the muscles for speech, yet their voice never fails to show a want of delicate direction, which the ear can alone supply; hence the monotony of their expression so characteristic of this deficiency.

As the rays of light by which we acquire a knowledge of external objects are inverted in the eye, so that images are painted reversed, it has been a problem of difficult solution to account for the correspondence of the impressions received through the eye, with those received through the touch; for it is obvious, that any want of correspondence must of necessity lead to confusion. There are some circumstances connected with the subject of voluntary movement now under consideration, which bear upon the explanation of this seeming contradiction. The eye presents us with two sensitive surfaces — the anterior and exposed part having sensation common to that of the surface generally, and the posterior and deeply seated part for the reception of luminous rays (the retina), having its own special reaction. By the rotation of the globe upon its axis, these

surfaces are necessarily moved at the same time in opposite directions as regards superior and inferior. This inversion of movement produces a correspondence between impressions made upon the surface of the body and those which result from the stimulus of light upon the retina; for the same movement which directs the transparent and exposed surface upwards, also brings the retina downwards into those rays of light, which, coming from above have undergone inversion in the eye by refraction.—But if the same voluntary movement places both sensitive surfaces in the same relation to the object, there can be no want of correspondence.

In no instance in the body is the connexion between sensitive surface and muscular movement more exact, than in the necessary convergence of the optical axes of the two eyes upon the same object, in order that we may receive a single impression. This necessary consensual movement seems to lie at the foundation of a curious and hitherto unexplained arrangement in the nervous system. It is well known that the right hemisphere of the brain presides over the movements of the left side of the body, and the left hemisphere over the right side of the body. It is equally determined that the left optic centre (optic lobe) is in relation with the right eye and *vice versâ:* so that blindness of the opposite eye follows upon disease or injury of either optic lobe. By means of this crossed relation (the third pair of nerves being an exception) the eyes are by the action of one hemisphere made to converge upon an object when it is situated either to the right or left side with the same facility as when the object lies directly in front of the two eyes and affects both hemispheres.

The relation of objective impressions to animal movements seems to be an essential one. In the lower series of such phenomena (the physical, aisthesical, and emotional,) external impressions are sufficient, without any implication of the will, to bring out their naturally associated results; but in the exercise of volition, though sensation takes a subordinate position as a cause, it has an essential office as guiding us to the instinctive use of that complicated arrangement of parts, of whose existence we are naturally ignorant, and which rightly to know challenges our highest efforts.— And not only does sensation thus guide us in the beginning, but when our voluntary actions have been often repeated, it stands in a yet closer relation, and forms the basis of habit, so far as it depends upon mechanical skill. By habit, the suggestions of sense call forth the most complex movements, and so spontaneously that they seem the expressions of a natural law requiring only the *assent of the will for their performance.*

W. W. G.

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In the Library, were exhibited: —

A Chinese Sun-dial and model of a Chain-pump; and Chinese and Hindu playing-Cards; Chinese Document, with the Em-

**peror's autograph, and Sir George Staunton's Credentials to the Court of Japan and Cochin-China [by the Royal Asiatic Society].**
**Bodley's Revolving and Sliding Window-Sashes [by Mr. Bodley].**
**Specimens of Plumose Alum and Minerals [by the Pharmaceutical Society].**
**Enlarged Model of the Lever Scapement [by Mr. Bishop].**
**A Small self-inking Printing Apparatus [from the Bank of England].**
**Talbotypes — Portraits and Views [by Messrs. Henneman and Malone].**
**Patent Pearl Glass Pictures [by Mr. Lane].**

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## WEEKLY EVENING MEETING,

Friday, March 21.

SIR CHARLES FELLOWS, V. P. in the Chair.

MR. BROCKEDON,

*On some Properties peculiar to Caoutchouc, and their Applications.*

CAOUTCHOUC is a vegetable constituent, the produce of several trees; the most prolific in this substance are, *Siphonia Caoutchouc*, *Urceola Elastica*, *Ficus Elastica*, *&c.*; of these the *Siphonia Caoutchouc* extends over a vast district in Central America, and the caoutchouc obtained from this tree is best adapted for its manufactures. Over more than 10,000 square miles in Assam the *Ficus Elastica* is abundant. The *Urceola Elastica* (which produces the Gintawan of the Malays,) abounds the islands of the Indian Archipelago. It is described as a creeper in in of growth so rapid, that in five years it extends 200 feet, and is from 20 to 30 inches in girth. This tree can, without being injured, yield by tapping, from 50 to 60lbs. of caoutchouc in one season. A curious contrast is exhibited in the tardy growth of the tree from which the Gutta Percha is obtained. This tree does not come to its prime in less than from 80 to 120 years. The produce cannot be obtained but by the sacrifice of the tree. It is found in a concrete state between the bark and the wood after the tree has been cut down, and it is in this condition that, having been scraped out, it is sent to our market.

When coagulated by evaporation or agitation, caoutchouc separates from the aqueous portion of the sap of the trees which yield it. This solid and fluid cannot afterwards be reunited, any more than butter is capable of mixing with the milk from which it is separated. Caoutchouc is a hydro-carbon. This chemical character belongs to all varieties of the substance, and many other vegetable constituents, though they differ materially in physical qualities. Some specimens

are harder than Gutta Percha itself, while others never solidify, but remain in the condition of bird-lime or treacle.

The process termed the *vulcanizing* of caoutchouc was discovered by Mr. Thomas Hancock in 1843.— A sheet of caoutchouc immersed in melted sulphur absorbs a portion of it, and at the same time it undergoes some important changes in many of its characteristic properties. It is no longer affected by climatic temperature; it is neither hardened by cold, nor softened by any heat which would not destroy it. It ceases to be soluble in the solvents of common caoutchouc, while its elasticity becomes greatly augmented and permanent.

The same effect may be produced by kneading sulphur into caoutchouc by means of powerful rollers; or the common solvents, naphtha and spirit of turpentine, may be charged with a sufficient amount of sulphur in solution to become a compound solvent of rubber. In these cases articles may be made in any required forms before heating for the change of condition. It is necessary, however, for this purpose, that the form should be carefully maintained during the exposure to the heat necessary to effect the vulcanization which leaves it in a normal state. A vulcanized solid sphere of $2\frac{1}{2}$ inches in diameter, when forced between two rollers $\frac{1}{4}$ inch apart was found to maintain its form uninjured. In fact, it is the exclusive property of *vulcanized* caoutchouc to be able to retain any form impressed upon it, and to return to that form on the removal of any disturbing force which has been brought to act upon it.

Caoutchouc slightly expands and contracts in different temperatures; it is also capable of being condensed under pressure. A cube of $2\frac{1}{4}$ inches, impactly secured, was subjected to a force of 200 tons. The result was a compression amounting to $\frac{1}{10}$; — great heat appeared to have been evolved, and the excessive elasticity of the substance caused a fly-wheel weighing five tons to recoil with an alarming violence.

The evolution of heat from caoutchouc under condensation is a property possessed by it in common with air and the metals. It differs, however, from the latter in being able to exhibit cold by reaction. Mr. Brockedon stated that he had raised the temperature of an ounce of water 2° in about 15 minutes by collecting the heat evolved by the extension of caoutchouc thread: he refers this effect to the change in specific gravity. He contends that this heat thus produced is not due to friction; because the same amount of friction is occasioned in the contraction as in the extension of the substance, and the result of this contraction is to reduce the caoutchouc thus acted upon to its original temperature.

Among the latest applications of the elastic force of caoutchouc — the chief purport of Mr. Brockedon's lecture — attention was directed:

1. To Mr. E. Smith's Patent application of tubes of vulcanized caoutchouc as *torsion springs* to roller blinds,— adjusted to the heaviest external blinds of houses, or the most delicate carriage blinds; and

equally applicable to clocks and various machines as a motive power.

2. To the *raising of weights* (Mr. Hodges' Patent application).— Short lengths of caoutchouc (termed by him Vulcanized *power-purchases*) are successively drawn down from or lifted to a fixed bearing, and attached to any weight which it is required to raise; when a sufficient number of these power-purchases is fixed to the weight, their combined elastic force lifts it from the ground. Thus ten purchases of the elastic strength each of 50lbs. raise 500 lbs. Each purchase is six inches long and contains about $1\frac{1}{2}$ oz. of vulcanized caoutchouc. These ten purchases, if stretched to their limit of elasticity not of their cohesive strength, will lift 650 lbs. This power — the accumulation of elastic force — though it obey the common law of mechanical powers, differs enough to be distinguished as a new mechanical power.

The same principle is applicable to relieve boats in tow from the strain they are subject to, and to easing the strain on ship's cables, especially where several boats are towing one vessel.

3. Applied as a *projectile force*. A number of power-purchases, attached to the barrel of a gun constructed to project harpoons, will exert a power if suddenly relieved proportioned to their aggregate forces.

Similar contrivances have been made for projecting balls 200 yards or more: a charge of No. 4. shot can be thrown 120 yards. On the same principle a bow was contrived in which (reversing the usual form) the string alone was elastic; this bow throws a 30-inch arrow 170 yards.

There were also exhibited adaptations of this material, for restraining furious horses,— for slinging horses whose limbs have been broken,— for enabling bed-ridden persons to assist themselves,— for strengthening feeble joints, and many other new and valuable purposes. W. B.

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In the Library, were exhibited: —

An antique Atlas (said to have belonged to Prince Talleyrand) drawn on parchment by Nicolas Vallard of Dieppe, in 1547, illuminated in the style of the ancient Missals, and illustrated with views of the various countries and figures of their inhabitants and animals, and upon which a Lecture was read before the Institute at Paris, in 1807, by M. Barbier duBocage [by Sir Thomas Phillipps, Bart. M.R.I.]

British Minerals [presented by Adam Murray, jun. Esq. M.R.I.]

Piece of Stucco from the Alhambra, and of Tessellated Pavement from Glastonbury, Models of Rudders, a Persian Astrolabe, &c. [from the United Service Institution].

Fish from the Red Sand-Stone, Fifeshire [J. Tennant, Esq.]

Specimens of Gutta Percha Manufacture [Messrs. Thorn & Co.]

[FOR THE USE OF MEMBERS.]

# Royal Institution of Great Britain.

1851.

## WEEKLY EVENING MEETING,

Friday, March 28.

WILLIAM POLE, ESQ. M.A. F.R.S. Treasurer, in the Chair.

NEVIL STORY MASKELYNE, ESQ., M.A.

*On the Connexion of Chemical Forces with the Polarization of Light.*

ANY facts which can throw light upon the ultimate molecular structure and condition of chemical compounds, cannot fail of possessing interest of a high character, as well for those whose thoughts only casually dwell upon questions of physical science, as for the mathematician and the chemist. To the mathematician, indeed, they would, if completely unfolded, supply the data for him to undertake the resolution of the questions of chemical combination and chemical change, by treating them as problems involving the action of mechanical laws; to the chemist, the acquisition of such knowledge would be the removal of some of the profoundest difficulties of his philosophy: but such knowledge is only to be sought in the most difficult paths of the whole range of science. The question of the connexion of chemical type with crystalline form, the fruitful cause of so much contention among mineralogists as to the questions of mineral species, is one on which we have no complete and sure knowledge; for the facts of dimorphism show, that implicated with this question are the actions of other forces, such as electric condition, and above all the mysterious molecular alterations induced by heat. Another direction in which such inquiries have been pursued, has been in tracing the phenomena resulting from the property possessed by many bodies, of modifying a plane-polarized ray of light, by what is termed circular-polarization. This property, from its being proved to be, in a large number of cases, an expression of the *molecular* structure of the substance, and as such inseparable in many cases from its chemical existence, may be taken, whenever this can be shown to be the case, as an evidence of its individuality, and may be used to determine the question of the permanency or transitory character of the molecular type of the substance. The information thus gained may be but vaguely defined, and the truth but darkly seen, yet does it nevertheless afford a valuable and interesting point of view for studying the molecular nature of bodies,

M. Biot has been for forty years enriching chemico-physical science by a series of memoirs detailing the results of his study of these phenomena. He has there shown the value of this means of tracing changes in chemico-molecular constitution.

M. Pasteur has carried forward this inquiry into a new channel by tracing a connexion between this property in substances, of circularly polarizing light, and their crystalline character.

But as it would be impossible to explain the nature of his investigations, or their results, without a preliminary knowledge of the meaning of the terms "circular polarization," and "hemihedrism," it was necessary first to enter a little upon the explanation of them.

Accordingly a ray was explained as being a direction of light, having no relations to space which differed from each other in directions perpendicular to its length. Thus without complicating the subject, by using the language of the beautiful wave-theory, a ray might be imagined as a cylinder of minutest diameter but indefinite length. When such a ray is reflected at a certain angle from glass or such like substance it is split into two; one going into, and through the glass if it be not opaque, the other being reflected from it. These two rays no longer possess the same "absence of sides" as the original ray. For the one has been as it were flattened down to a "strip," while the other has also been flattened similarly into a "strip," but the latter strip is at right angles in regard to its "flattened plane" to what the other is. A similar bifurcation of the ray is produced in the interior of what are called doubly refracting crystals. This bifurcation and flattening of the ray is termed "plane polarization" of it; and it is so far a true instance of polarity—as that the two rays have equal and similar properties in opposed directions.

This was exhibited by the Lime-light. The double image of a small round hole formed by a crystal of Iceland spar was thrown on a screen, and each beam shown to be most capable of reflection in a plane in which the other was incapable of being reflected at all. The action of the tourmaline as a doubly refracting crystal which absorbs one of the rays was then explained; and it was shown that the position of the tourmaline in which it intercepted one ray entirely, was exactly the position in which it gave the other ray free passage. The optic axis of a crystal was then defined to be a direction in it along which the light could pass through the crystal without undergoing any change whatever. The central ray of a polarized beam of light, traversing a piece of calc spar along its optic axis, was shown to be intercepted or transmitted by a tourmaline, precisely as if the section of the crystal of calc spar were away.

An exception was however stated to exist to this law of the neutrality of the optic axis. When a section of quartz, cut so that the beam could career along its optic axis, was put in the path of the polarized ray, it was found that instead of permitting the ray to be eclipsed by the tourmaline when this was placed in the position

to eclipse it, that ray on the contrary fell on the screen endowed with beautiful colour; and furthermore that the revolution of the tourmaline induced the most brilliant succession of colours, in the order, in the instance exhibited, of red, plum-colour, blue, green, orange, red. It was shown, however, that another specimen exhibited these colours in the reverse order of red, orange, green, blue, plum-colour, red; in which order the former specimen of quartz produced these colours when the tourmaline was turned in the *opposite* direction. Hence these are termed right and left handed polarizations. The whole of these phenomena were attributed to a complicated set of movements of the light within the crystal, the *resultant* of which was practically a rotation of the plane in which the ray was capable of being reflected,—so that the thicker the crystal, the further round the tourmaline had to be turned to permit the ray to pass it, or to be eclipsed, as the case might be. The opposite order of the colours was explained by the fiction of supposing the one to be the effect of a left handed thread to the screw and the other of a right handed thread characterizing the spiral in which the plane of polarization was supposed to rotate. Of course this was only a popular way of explaining the phenomenon, it being really due to a more complicated series of movements which were explained by Fresnel in the most triumphant manner by the wave theory.

The colour was accounted for by the idea of the red following a longer spiral (having a coarser thread to the screw) than that of the orange, this than the yellow, and so on up to the violet. Without the tourmaline in front all would emerge and form white light; but the tourmaline only allows such rays to pass it as are capable of passing it in its particular position; *i. e.* only such, the rotation of whose plane has brought them round to the position of the plane in which the tourmaline lets the light through.

The singular fact of amethyst being a combination of alternate layers of right and left-handed quartz was then exhibited, both by throwing the image of the alternate layers on the screen, and afterwards by showing that the general effect of a traversing polarizing beam was to produce a neutrality of action. Other substances, however, produce phenomena of circular polarization. Uncrystallized, fused tartaric acid, and barley sugar, &c. produce them; and these bodies when dissolved, and many more in the form of liquids also, do so, some of which were exhibited. But the silica of which quartz consists entirely loses this property when divested of its crystalline character, whether artificially or in its natural state as calcedony, opal, &c. All other bodies retain it so long as their chemical molecule retains its individuality of character.

The next point to be made clear, was the meaning of that form of crystallographic developement called "Hemihedrism." Haüy's great law was, that similar edges or angles were always similarly modified. The nature of similarity in edges or angles was then pointed out, and the general idea of many crystallographers of a

sort of nucleus or primitive form existing on which the crystal was formed, was explained, as also the nature of the developement of such a crystal by the modifications placed on the edges and angles according to the law before mentioned. But the exception to that law was not less remarkable for its generality of character than the law itself. This exception consists in the fact that very often crystals are found in which not every similar edge or angle was modified, but where every *alternate* similar edge or *alternate* similar angle was so. This circumstance was then illustrated by the actual truncation of some models; and it was shown that such alternately developed or *hemihedral* crystals may be *right* and *left*, the upper terminal modification being to the right in the one case, and the corresponding and similar lower terminal modification being then to the left, while in the other case they are exactly the converse. Hence, one crystal is, as Pasteur describes it, "*non superposable*" to the other; the one is as the image of the other reflected in a mirror, as the right hand is compared to the left.

A beautiful connexion was then pointed out, as established long ago by the acute observation of Sir J. Herschel, that the plagiedral facettes of quartz indicated, by their relative positions on the crystal, the direction in which the crystal would rotate the plane of polarization. The crystallographic character of these facettes was then pointed out, and their connexion shown with this hemihedrism. But the most beautiful instance of the connexion of hemihedrism in crystals with the direction of the rotatory power of the substance of which they are composed is afforded by the recent discoveries of Pasteur, which may now be almost traced to a law, enunciated thus: that where a substance is hemihedric when crystallized, and possesses the rotating character, the direction of the rotation is indicated by the nature of the hemihedrism.

Paratartaric acid was then introduced. It was described as extremely like tartaric acid in its chemical reactions and identical with it in composition. It was similarly formed to the latter, and was found only one year in the cream of tartar of the wine of the Vosges. Pasteur separated the crystals of the Paratartrate of soda and ammonia into two several sets; the one set he showed to be hemihedric to the right, the other set to the left. The former proved to be the salt of an acid rotating to the right, the latter of one rotating to the left. On examining these acids they were found in every single property, but this rotation, identical with one another and with tartaric acid. Yet when mixed they formed again the Paratartaric acid, which, like the amethyst, is without any action of a rotatory character, and the difference of which from the other two acids was then exhibited by the precipitation by the latter of a salt of lime which did not render either of the former turbid.

Mr. Maskelyne then detailed the experiments of M. Pasteur on malic and aspartic acids and asparagine, and showed how all of these could be understood to contain chemically a molecular unit

common to all these and perhaps to tartaric acid, and only modified a little by the super-position as it were of other substances, in combination with it, upon the extremities of its molecule.

He also dwelt on the possibility of the Paratartaric acid being a quadribasic as the tartaric acid is a bibasic acid; it being on this view a conjugate acid consisting of the two united tartaric acids. He then invited attention to the interesting nature of M. Biot's investigation of the action of tartaric acid in solution in water, and he showed that here the acid must be supposed capable of combining with an indefinite or indeed an infinite amount of water, while in other cases again, bodies (such as sugar for instance) exercise no effect upon the water and do not seem to *combine* with, but only to be dissolved in it. The former is an instance of a *continuous* and not *intermittent* sort of combination; and though we need not anticipate a recurrence of the controversy of Berthollet and Proust, yet this shows us that the actions of quantity or mass so dwelt on by the former are not without a great significance; and that the power that can thus enable us to determine such important points in chemical statics, is well worthy of the attention of the philosophic mind.

Dr. Bence Jones permitted a Saccharimeter apparatus of Soleil's, on the double-quartz-plate principle, to be exhibited, and explained its use. Mr. Tennant also exhibited a mass of quite transparent Iceland spar, and a beautiful crystal of plagiedral quartz.

Since the delivery of the lecture, a letter has been received from M. Pasteur stating that he had forwarded for exhibition at and illustration of this lecture, all the finest specimens of the crystals which he has produced, which are further illustrated by models and diagrams. They are the same as those which were exhibited at the Academy of Sciences at Paris, and the liberality of M. Pasteur's act will be appreciated by Members of the Royal Institution, when they are reminded that the Paratartaric acid of which they are the products is impossible to be obtained, from its having only once been accidentally formed, and that these specimens therefore consist probably of the only large accumulation of this body in existence. As soon as they arrive they will be exhibited to the Members.

NEVIL STORY MASKELYNE.

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In the Library were exhibited: —

An Apparatus exhibiting the colours produced by Polarized Light, [by Mr. Newman].

Specimens of Pyramidal Alum Crystals, Metallic Arsenic from California, Chrome alum crystals — Nitrate of Potash — Tincal or Native Borax, and Metallic Antimony [by the Pharmaceutical Society].

Sanskrit MSS. — Ancient Pictures of Akbar and his Court, and Jehangír and his Court [by the Royal Asiatic Society].

Models and Diagrams to illustrate a New Theory of Nāvāl Architecture [by Mr. W. E. Hall].

## WEEKLY EVENING MEETING,

Friday, April 4.

H. R. H. Prince Albert, Vice Patron, in the Chair.

Sir Charles Lyell,

*On Impressions of Rain-drops in Ancient and Modern Strata.*

Foot-prints of reptiles and birds have been observed on the surface of several ancient strata, accompanied by cracks resulting from the shrinkage of mud during desiccation, and it had been fairly inferred that the rocks bearing these marks must have been formed on a beach, between the level of high and low tide. It might therefore have been presumed that the same combination of circumstances would favour the preservation of impressions left by rain-drops, if any rain had fallen on the surface of the same strata, when in a state of mud or sand. Accordingly, memorials of rain have been met with, and Sir Charles Lyell exhibited specimens of fossil rain and hail-prints, collected by Mr. Redfield of New York, from the New Red Sandstone of triassic age in New Jersey, and others of still older date, obtained by Mr. Richard Brown, from green slabs and sandstones of the Coal Measures of Cape Breton in Nova Scotia.

Casts of rain-drops were first recognized in 1828 by Dr. Buckland on the lower surfaces of slabs of quartzose sandstone, found by Mr. Cunningham in the Storeton Hill quarries in Cheshire, where they are accompanied by shrinkage cracks, foot-prints of Cheirotherium, and ripple marks. Mr. Redfield and Sir C. Lyell observed others at Newark in New Jersey in 1841, in red sandstone and shale; and still finer examples have been since met with at Pompton, in the same state, twenty-five miles from New York, by Mr. Redfield. The Lecturer had also an opportunity of observing, in 1842, that a shower of rain had left numerous impressions on the mud-flats exposed at low water, in estuaries communicating with the Bay of Fundy; and he afterwards obtained a collection of specimens of the hardened mud from Dr. Webster of Kentville, some of which are marked by the drops of a heavy but transient shower which fell on the 21st of July, 1849. The average size of the hemispherical cavities is small, but some of them are no less than half an inch in diameter. Many of them are circular, but in some the longest diameter exceeds the shortest by $\frac{1}{8}$th, or even $\frac{1}{3}$rd. They are surrounded by a small rim of mud, consisting of the matter which has been forcibly expelled from the pit by the falling drop; and this marginal rim sometimes projects as much above the plane of the stratum, as the bottom of the pit ex-

tends below it. In those impressions which have been made when the wind was blowing, and when the rain fell obliquely, the cavities are not only of an oval shape, but all deeper at one end than at the other. Foot-prints of birds, and the winding tubular tracks of annelids are seen on the same surface with the rain-prints. On splitting open slabs formed by numerous thin layers deposited by successive tides, impressions of previous showers are seen, and casts of the same, standing out in relief on the under surface of incumbent layers.

The Lecturer next considered the nature of certain small protuberances, which might, on a cursory view, be mistaken for casts, which project from the upper surface of certain layers of mud, and are caused, some of them by dried bubbles of mud, and others by small particles of solid matter, covered with a film of mud. He also distinguished between the cavities produced by air-bubbles rising up through the mud, which give rise to cavities differing in shape from those formed by rain, as he has proved by several experiments.

In illustration of the foot-tracks of quadrupeds, such as the musk-rat, the minc, the dog and others, so common on the recent red sand of Kentville, on the borders of the Bay of Fundy in Nova Scotia, Sir C. Lyell exhibited a copy of a brick, one foot square from Babylon, now in the British Museum, on which the track of a small animal of the Ichneumon tribe, apparently the Asiatic Mongoose, is distinctly seen. This brick has been sun-dried (not baked in a kiln,) and must have been traversed by the creature, when the clay mixed with straw was still very soft. In the middle of the brick is an inscription in the Babylonian cuneiform character, which according to Colonel Rawlinson's interpretation signifies that Nabokodrossor, King of Babylon, built certain cities, &c. This king is the same as the Nebuchadnezzar of scripture, so that the brick is twenty-four centuries old.

When the tidal waters densely charged with fine sediment creep gently over a slightly inclined sand or mud-bank, they do not disturb the surface, especially when it has been baked hard in the sun, as happens in summer in Nova Scotia; and the new layer of matter which is thrown down, fills up all superficial indentations, which serving as moulds are protected from further disturbance by the casts thus taken from them.

Mr. Cunningham threw out as a conjecture, that the fine-grained quartzose substance of Storeton Hill, might have resulted from blown sand. That such was really its origin, Sir C. Lyell, who has himself examined the quarries on the Mersey, entertains little doubt; for on the sea-shore near Savannah in Georgia, he saw the foot-tracks of raccoons and opossums which had been made in sandy mud at low water, in the course of being gradually filled up with blown sand, clouds of which were swept along by the wind from adjoining cliffs. This layer of sand when the tide rose again would in its turn be overspread by a new deposit of mud.

After describing both the impressions and casts of rain occurring in the recent red mud of the Bay of Fundy, the Lecturer pointed

out their close analogy with markings inscribed on triassic slabs of sandstones in New Jersey, on which also ripple-marks, shrinkage cracks, and foot-prints of birds have been observed. The character of these ancient impressions may sometimes be seen to vary where the rain has fallen obliquely on rippled surfaces, the cavities being deeper on the windward and shallower on the leeward sides of the ridges formed by the ripple. Casts of rain-prints are seen on the lower surface of several sandstone strata. The direction of the rain is usually distinguishable, the longest diameters of the cavities being all parallel, and their deepest ends all on the same side. The markings attributed by Mr. Redfield to hail, are deep, irregular in form, and extremely angular in outline; and the walls are steeper, especially at the deepest extremity of the excavation where they often overhang.

The carboniferous rain-prints of Sydney, Cape Breton, observed by Mr. Richard Brown, are some of the most delicately sculptured on the laminæ of shale. In some specimens they are quite separate from each other, most of them oval and with distinct rims. Mr. Brown remarks that they only extended over a certain narrow zone, disappearing when the stratum containing them was traced further in each direction; so that they appear to have constituted a narrow belt, as might be expected if they were formed on a sea beach. For when rain falls on recent mud bordering the Bay of Fundy, impressions are only made on one portion of the exposed surface, the upper part of the bank (left dry for ten days or more after the highest spring tides,) being too hard to receive any imprints, and the lower part near the water's edge being too soft. In some shales from Cape Breton, perfect casts are seen projecting from an under surface where the drops are few in number, while in another stratum distinct casts of a heavy shower are preserved in a fine-grained sandstone which presents a warty and blistered appearance. The casts also of small cracks, which must have traversed the subjacent clay, stand out in relief. Together with these memorials of rain are seen numerous winding cylindrical cavities, open at the top and precisely resembling these now formed by annelids on the recent mud of the Bay of Fundy. These strata occur in the same series of beds, in which so many examples of buried forests occur, with the trunks of trees standing erect, and having their roots attached to them. There are also numerous rippled sandstones at different levels in the same formation.

On re-examining the slab which he brought in 1846 from the coal-strata of Greensburg, Pennsylvania, on which Dr. King first found impressions of a carboniferous reptile, Sir C. Lyell finds not only shrinkage-cracks but a multitude of small tubercles covering the surface resembling the casts of rain-prints, and which he can scarcely doubt are referable to pluvial action.

In conclusion, the Lecturer enlarged on the important inferences deducible from the discovery of rain-prints in rocks of such remote

antiquity. They confirm the ideas entertained of the humid climate of the carboniferous period, the forests of which we know were continuous over areas several hundreds of miles in diameter. The average dimensions of the drops indicate showers of ordinary force; and show that the atmosphere corresponded in density as well as in the varying temperature of its different currents with that which now invests the globe. The triassic hail, moreover, implies that some regions of the atmosphere were at this epoch intensely cold; and coupled with the foot-prints, worm tracks, ripple-marks, and the casts of cracks formed by the drying of mud, these impressions of rain clearly point to the existence of sea-beaches where tides rose and fell, and therefore lead us to presume the joint influence of the moon and sun. Hence we are led on to infer that at this ancient era, the earth with its attendant planet was revolving, as now, round the sun, as the centre of our system, which probably belonged then as now to one of those countless clusters of stars with which space is filled.

C. L.

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In the Library, were exhibited: —

Marine Worm from Tale-bank Quarry, Wensleydale, Yorkshire [presented by F. H. Gabriel, Esq., M. R. I.]

Transparent Iceland Spar; an ancient Alabaster Canopic Vase, and a Vase in marble from Old London Bridge [by Mr. Tennant].

Model of Nelson Column, Yarmouth; Calabashes, Weapons, Cloth and Needle from New Guinea, &c. [from the United Service Institution].

Grotesque Figure (naturally formed) in Marble [by Mr. Eades].

Turn-tables showing various Modes of diminishing Friction [from the Royal Polytechnic Institution].

Model of an Anti-Friction Wheel-Carriage, &c. [by Mr. Coles].

A delicate Balance for Chemical Analyses [constructed by J. W. M. Marriott, Esq., M. R. I.]

Shakspearean Shield (a design for a bas relief by Luke Limner, Esq.) and Specimens of Bookbinding [from Messrs Leightons].

Specimens of Imitation Ivory [by Mr. B. Chiverton].

## GENERAL MONTHLY MEETING.

Monday, April 7.

William Pole, Esq., M.A., F.R.S., Treasurer, in the Chair.

Francis Bayley, Esq.
John J. Bigsby, M.D. F.G.S. &c.
Allen Davis, Esq.
Rev. Joseph Hambleton, B.D.
The Lord Moreton.
Henry Twining, Esq.
James S. Willes, Esq.

were *admitted* Members of the Royal Institution.

Hugh M. Cairns, Esq.
Alexander Matheson, Esq. M.P.
Edward Thornton, Esq.

were duly *elected* Members of the Royal Institution.

The Secretary announced that the Actonian Prize of One Hundred Guineas had been adjudicated to Thos. Wharton Jones, Esq. F.R.S. for an "Essay on the Senses in General, and on the Sense of Vision in particular, as illustrative of the Wisdom and Beneficence of the Almighty."

A Donation of £10. from John Pepys, Esq. M.R.I. was reported, and the warmest thanks of the Members voted to Mr. Pepys for this additional act of liberality to the Royal Institution.

The following Presents were announced, and the thanks of the Members ordered to be returned for the same;—

From
*Jacob Bell, Esq. M. P. M.R.I. (the Editor)*.—Pharmaceutical Journal, March and April, 1851. 8vo.
*The Editor*—The Athenæum for February and March, 1851. 4to.
*The Statistical Society of London*—Journal, Vol. XIV. Part I. 8vo. 1851.
*Messrs. Reeve and Benham (the Publishers)*—The Literary Gazette for Jan. and Feb. 1851.
*Professor Faraday (the Author)*—Researches in Electricity, Series 24—27. 4to. 1851.
Monatsberichte der Königl. Preuss. Akademie für Jan. 1851. 8vo.
Signatures of some Eminent Fellows of the Royal Society, lithographed from the Charter-book (for Private Circulation by C. R. Weld). 4to. 1851.
*The Institution of Civil Engineers*—Proceedings for March, 1851. 8vo.
*The Royal Institute of British Architects*—Proceedings for March, 1851. 4to.

*The Royal Society of Literature* — Transactions, Second Series, Vol. II. and III. 8vo. 1847—50.

Proceedings, Vol. I. Nos. 1 — 20. 8vo.

*W. Spence, Esq.* — Portrait of Rev. W. Kirby, F.R.S. &c. with Sketch of his Life and Works.

*W. B. Carpenter, M.D. F.R.S. (the Author)* — On the Mutual Relations of the Vital and Physical Forces. 4to. 1851.

*The Author* — The Apology of an Israelite for not becoming a Christian. 12mo. 1851.

*Charles Babbage, Esq. (the Author)* — Thoughts on the Principles of Taxation with Reference to a Property Tax, &c. 8vo. 1851.

*John Prosser, Esq. Life-Sub. R. I.* — Atlas Géographique et Physique de Nouvelle Espagne, fondé sur les Observations Astronomiques, etc par M. Alex. de Humboldt. fol. Paris, 1812.

Hone's Satirical Tracts: — The Political House that Jack built, &c. 8vo. 1819-20.

A Letter from the King to the People. 8vo. 1820.

The Queen's Rights and the People's Wrongs. 8vo. 1820.

Tracts, in one vol.: viz. — Age of Reason, by T. Paine; Reply by Gilbert Wakefield; — Priestley's Letter to the Philosophers and Politicians of France, &c. &c.

Tracts circulated by the National Anti-Corn-Law League. 8vo. 1842.

*Joseph G. Cogswell, Esq.* — Alphabetical Index to the Astor Library. 8vo. New York, 1851.

*The Author* — Letters on Church Matters; by D.C.L., Vol. I. 8vo. 1851.

*The Trustees of the British Museum* — Vetus Testamentum Græcum e Codice MSS. Alexandrino, &c. curâ et labore H. H. BABER, A. M. 3 tomi. fol. 1816—21.

Descriptions of the Ancient Terracottas. 4to. 1810.

Descriptions of the Ancient Marbles, Pt. 1—10. 4to. 1812 — 1845.

Nummi Veteres in Museo, R. P. Knight ab ipso descripti. 4to. 1830.

Catalogue of the Anglo-Gallic Coins. 4to. 1826.

Catalogue of the Hargrave Manuscripts. 4to. 1818.

Catalogue of the Burney Manuscripts. fol. 1840.

Index to the Arundel and Burney MSS. fol. 1840.

Catalogue of the Oriental MSS. Part 1 — 3. fol. 1838 — 41.

Catalogue of the Manuscript Music. 8vo. 1842.

Catalogue of the MSS. Maps, Charts, and Plans, 2 vol. 8vo. 1844.

Greek Papyri, Part 1. 4to. 1839.

Select Papyri in the Hieratic Character, Part 1 — 3. fol. 1841—44.

List of Mammalia. 12mo.

Catalogue of Mammalia, Part 1 and 2.

List of Mammalia and Birds of Nepal, presented by B. H. Hodgson, Esq. 12mo. 1846.

List of Additions to the MSS. 1841 — 1845. 8vo. 1850.

List of Birds, Part 1 — 3. 12mo. 1844 — 8.

Catalogue of Reptiles; Part 1, Tortoises, &c. Part 2, Lizards. Part 3, Snakes. 12mo. 1844—9.

Catalogue of Amphibia, Part 2. 12mo. 1850.

List of Osteological Specimens. 12mo. 1847.

List of Lepidopterous Insects, Parts 1 and 2, and Appendix. 12mo. 1844 — 8.

List of Hymenopterous Insects, Part 1 and 2. 12mo. 1846 — 48.

List of Dipterous Insects, Part 1 — 4. 12mo. 1848 — 49.

Nomenclature of Coleopterous Insects, Part 1 — 4. 12mo. 1847 — 9.

List of Crustacea. 12mo. 1847.

List of Myriapoda. 12mo. 1844.

Catalogue of the Mollusca, Part 1 and 2. 12mo. 1849 — 50.

Catalogue of Bivalve Mollusca, Part 1. 12mo. 1850.

*The Trustees of the British Museum*, continued: —
Nomenclature of Molluscous Animals and Shells. 12mo. 1850.
List of Homopterous Insects, Part 1. 12mo. 1850.
List of the British Animals, Part 1, Radiata. Part 2, Sponges. Part 3, Birds. Part 4, Crustacea. Part 5, Lepidoptera. 12mo. 1848 — 50.
List of Donations, 1828 — 30. 4to.
Inscriptions in the Cuneiform Character from Assyrian Monuments discovered by A. H. Layard, D.C.L. fol. 1851.
*The Asiatic Society of Bengal* — Journal, Nos. 215, 216. 8vo. 1850.
*The Chemical Society* — Journal, No. 13. 8vo. 1851.
*The Geographical Society of Bombay* — Transactions, Vol. I. to VI. and Vol. VIII. Part 1. 8vo. 1836 — 1848.
*The Royal Society* — Proceedings, No. 59 and No. 77, parts 1, 2. 8vo. 1851.
Transactions for 1850, Part 2. 4to. 1851.
List of Members for 1850. 4to.
*Adam Murray, jun. Esq. M. R. I.* — Specimens of British Minerals.
*F. H. Gabriel, Esq. M. R. I.* — Fossil Marine Worm from Tale-bank Quarry, Wensleydale, Yorkshire.
*Wm. Bollaert, Esq.* — Specimens of Minerals collected in the Texas (vide Trans. Geog. Soc. 1843 — 49.)

## WEEKLY EVENING MEETING,

Friday, April 11,

H. R. H. Prince Albert, Vice Patron, in the Chair.

Professor Faraday

*On Atmospheric Magnetism.*

On a former evening (*January* 24, *page* 1) it was shown that Oxygen gas was magnetic, being attracted towards the poles of a magnet; and that like other magnetic bodies, it lost and gained in power as its temperature was raised and lowered, and that the change occurred within the range of natural temperatures. These properties it carries into the atmosphere; and the object, this evening, was to show how far they might be applied to explain certain of the observed variations of the terrestrial magnetic force.

If a source of magnetic power be considered (as a magnet) it presents us with a system having polarity; and if the parts which are called the poles be taken as representing the most concentrated condition of the polarity, then the contrary polarities, manifest externally in relation to the magnet, are perfectly definite, being exactly equal to each other. If the magnet be irregular in the disposition of its force, still the same definite character of the sum of the contrary polarities holds good.

External to the magnet those concentrations which are named poles may be considered as connected by what are called magnetic

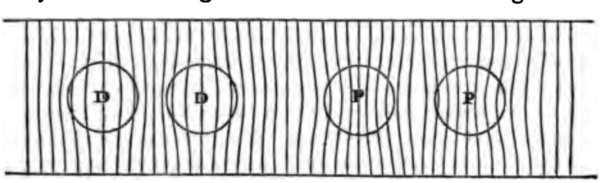
curves, or lines of magnetic force, existing in the space around. These phrases have a high meaning, and represent the ideality of magnetism. They imply not merely the directions of force, which are made manifest when a little magnet, or a crystal, or other subject of magnetic action is placed amongst them, but those lines of power which connect and sustain the polarities, and exist as much when there is no magnetic needle or crystal there as when there is; having an independent existence analogous to (though very different in nature from) a ray of light or heat, which, though it be present in a given space, and even occupies time in its transmission, is absolutely insensible to us by any means whilst it remains a ray, and is only made known through its effects when it ceases to exist. The form of a line of magnetic force may vary exceedingly from a straight line to every degree of curvature, and may even have double and complicated curvatures impressed upon it. Its direction is determined by its polarity, the two changing together. Its powers are such, that a magnetic needle placed in it finds its place of rest parallel to it; a crystal of calcareous spar turns until its optic axis is transverse to it; and a wire which is unaffected when moved in or along it, has an electric current evolved the instant that it passes across it: by these and by other means the presence of the magnetic line of force and its direction are rendered manifest.

The Earth is a great magnet: its power, according to Gauss, being equal to that which would be conferred if every cubic yard of it contained six one-pound magnets; the sum of the force therefore is equal to 8,464,000,000,000,000,000,000 such magnets. The disposition of this magnetic force is not regular, nor are there any points on the surface which can be properly called poles: still the regions of polarity are in high north and south latitudes; and these are connected by lines of magnetic force (being the lines of direction) which, generally speaking, rise out of the earth in one (magnetic) hemisphere, and passing in varied directions over the equatorial regions into the other hemisphere, there enter into the earth to complete the known circuit of power. A free needle shows the presence and direction of these lines. In London they issue from the earth at an angle of about 69° with the horizon (being the dip or inclination); and the plane in which they rise forms an angle of 23° W. nearly with true north, giving what is called west declination. Where the dip is small, as at the magnetic equator, these lines scarcely rise out of the earth and pass but a little way above the surface; but where it is large, as in northern or southern latitudes, they rise up at a greater angle, and pass into the distant realms of space, from whence they return again to the earth in the opposite magnetic hemisphere; thus investing the globe with a system of forces like that about an ordinary magnet, which wherever it passes through the atmosphere is subject to the changing action of its magnetic oxygen. There is every reason to believe that these lines are *held* in the earth, out of which they arise and by which they are produced, just as the

lines which originate in a magnet are held by it, though not in the same degree; and that any disturbance from above affecting them will cause a greater change in their place and direction in the atmosphere and space above, than in the earth beneath.

The system of lines of magnetic force around a magnet or the earth is related by a lateral tension of the whole, analogous in some degree to the lateral tension of lines of static electrical force; both the one and the other being easily made manifest by experiment. The disturbance of the tension in one part is accompanied instantly by a disturbance of the tension in every other part; for as the sum of the external powers of a system, unaltered at its origin, is definite and cannot be changed; so any alteration either of intensity or direction amongst the lines of force at one place, must be accompanied by a corresponding change at every other. So if a mass of soft iron on the east side of a magnet causes a concentration of the lines of force from the magnet on that side, a corresponding expansion or opening out of the lines on the west side must be and is at the same time produced; or if the sun, on rising in the east, renders all the oxygen of the air on that side of the globe less magnetic and less able therefore to favour the transition of the lines of terrestrial force there, a greater number of them will be determined through the western region; and even though the lines of force may be doubted by some as having a separate existence such as that above assumed, still no error as to the effects on magnetic needles would in that case be introduced, for they by experiment would be and are the same.

The power of a magnetic body as iron or oxygen to favour the transmission of lines of force through it more than other bodies not magnetic, may be expressed by the term conduction. Different bodies, as iron, nickel, oxygen, conduct in various degrees, and not only that, but the same body as iron or oxygen conducts in different degrees at different temperatures. When space traversed by uniform lines of magnetic force is occupied by a uniform body as air, the disposition of the lines is not altered; but if a better conducting substance than the air is introduced, so as to occupy part of the space, the lines are concentrated in it, and drawn from other parts as shown by P. P. in the figure, or if a worse conducting substance is




introduced, the lines are opened out as at D. D. In both cases the lines of force are inflected, and a small magnetic needle standing in them at the inflected part would have its direction changed accordingly. Experimental illustrations of these changes in direction are given

in Mr. Faraday's paper in the Philosophical Transactions for 1851, Part I. Par. 2843, &c.

Now this by the hypothesis is assumed to take place in the atmosphere. Supposing it all at mean temperature, the lines of force would have the direction determined by the arrangement of the power within the earth. Then the sun's presence in the east would make all the atmosphere in that region a worse conductor, and cause it to assume the character of D; and as the sun came up to and passed over the meridian and away to the west, the atmosphere under his influence would bring up changes in direction like those shown in either D or D; it would therefore manifestly set a needle in a given latitude in opposite directions as it passed by; and as evidently set two needles in north and south latitudes in opposite directions at the same moment of time. As the night came on and a temperature lower than the mean came up from the east and passed over, the lines of force would be inflected as in P or P., and a reverse variation of the needle to that which occurred before would now take place.

That natural effects of variation must be produced consequent upon the magnetic nature of oxygen and its daily variations of temperature is manifest; but whether they cause the observed variations, or are competent to do so, is a question that can only be decided after very careful enquiry. Observations are now made on the surface of the earth with extreme care in many places, and these are collated, and the average or mean result, as to direction and intensity of the earth's force, ascertained for every hour and season; and also many remarkable, anomalous, and extra results evolved. A theory of the causes of any or all of these variations may be examined first by the *direction* which the varying needle does or ought to assume, and then by the *amount* of the variation. The hypothesis now brought forward has been compared with the mean daily variation for all the months in the year at north and south stations, as Toronto and Hobarton, and at many others near to and far from the Equator, and agrees in direction with the results observed far beyond what the author anticipated. Thus the paths described by the upper ends of free needles in the north and south hemispheres should be closed curves, with the motion in opposite and certain directions, and so they are:—the curves described by needles in north or south latitudes should be larger in summer and smaller in winter, and so they are:—a night or cold action should grow up in the winter months, and such is the case:—the northern hemisphere ought to have a certain predominance over the southern, because of its superior temperature, and that is so:—the disposition of land and water ought to have an influence, and there is one in the right direction:—so that in the first statement and examination of the hypothesis it appears to be remarkably supported by the facts. All these coincidences are particularly examined into and stated in the Philosophical transactions already referred to. The next step will be to ascertain what is the

amount of change in the conducting power of the air for given changes of temperature, and then to apply that in the endeavour to ascertain whether the amount of change to be expected is (as well as the direction) accordant with that which really occurs.

M. F.

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In the Library were exhibited :—

Gilbert, de Magnete ; Kircher, de Arte Magneticâ ; Churchman's Magnetic Atlas ; and the Magnetical Observations at Greenwich, St. Helena, Toronto, and Bombay ; and Col. Sabine's "Unusual Magnetic Disturbances" [from the Royal Institution Library].
Minerals from Texas, collected and presented by W. Bollaert, Esq.
Portrait of Mr. Faraday by A. Blaikley, Esq.
Candelabras presented to the Marquis of Tweeddale [by Messrs. Hunt and Roskell].
Model of Anchor invented by Commander Inglefield, R.N. M.R.I.
Fairburn's Machine for Making Cotton-Cards [by Mr. Fairburn, C. E.]
"A Retriever ;" First Proof of an Engraving by H. T. Ryall, from a Drawing by Sir E. Landseer [by Mr. J. L. Grundy].
New Water-mark in Bank-note paper, and Specimen of Paper split in three [by Mr. Oldham].
Nine Flints with Fossil Sponges, &c. from Salisbury ; a large piece of Native Copper, with Native Silver, Calcareous Spar &c. part of a piece weighing 30 tons from Lake Superior [by Mr. Tennant].
Talbotypes and Photographs [by Messrs. Henneman and Malone].

[FOR THE USE OF MEMBERS.]

# Royal Institution of Great Britain.

## 1851.

## ANNUAL MEETING.

Thursday, May 1.

William Pole, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

The Annual-Report of the Committee of Visitors on the State of the Institution was read and adopted.

Thanks were voted to the President, Treasurer, and Secretary, to the Committees of Managers and Visitors, and to Professor Faraday, for their services to the Institution during the past year.

The following Gentlemen were unanimously elected as Officers for the ensuing year:—

President—The Duke of Northumberland, F.R.S.
Treasurer—William Pole, Esq. M.A. F.R.S.
Secretary—Rev. John Barlow, M.A. F.R.S.

### Managers.

Sir John P. Boileau, Bart. F.R.S.
George Dodd, Esq. M.P. F.S.A.
Sir Charles Fellows.
John Forbes, M.D. F.R.S.
W. R. Hamilton, Esq. F.R.S. F.S.A.
Sir Charles Lemon, Bart. LL.D. F.R.S.
Right Hon. T. B. Macaulay, M.A. F.R.S.
George Moore, Esq. F.RS. F.S.A.
Gen. Sir William Morison, K.C.B. M.P. F.R.S.
The Lord Overstone.
Frederick Pollock, Esq. M.A.
Lewis Powell, M.D.
John Webster, M.D. F.R.S.
Charles Wheatstone, Esq. F.R.S.
Col. Philip J. Yorke, F.R.S.

### Visitors.

John Bate Cardale, Esq.
William Carpmael, Esq.
John Lettsom Elliot, Esq.
Augustus Bozzi Granville, M.D. F.R.S. F.L.S.
William Johnston, Esq.
Henry Bence Jones, M.D. F.R.S.
Edward Kater, Esq. F.R.S.
George Macilwain, Esq.
Charles Blachford Mansfield, Esq.
Edward Meryon, M.D.
Henry Harwood Penny, Esq.
Henry James Prescott, Esq.
James Rennie, Esq. F.R.S.
William Noble Rule, Esq.
Alfred S. Taylor, M.D. F.R.S.

## WEEKLY EVENING MEETING,

Friday, May 2.

The Duke of Northumberland, President, in the Chair.

The Astronomer Royal,

*On the Total Solar Eclipse of* 1851, *July* 28.

The Lecturer remarked that the subject which he had suggested to the Managers of the Institution for the present Lecture might at first sight appear meagre and common-place, but that he believed it would be found to be one of the highest interest: first, because during a total eclipse we are permitted a hasty glance at some of the secrets of nature which cannot be seen on any other occasion: secondly, because the general phænomenon is perhaps the most awfully grand which man can witness. Many of his audience had probably seen large partial eclipses of the sun, and they might suppose that a total eclipse is merely an intensified form of a partial eclipse; but, having himself witnessed a total eclipse, he was able to assure them that no degree of partial eclipse up to the last moment of the sun's appearance gave the least idea of a total eclipse, as regarded either the generally terrific appearances, or the singular nature of some of the phænomena. Many years ago, in reading the admirable essay in the Philosophical Transactions by the late Mr. Baily on the eclipse (usually called that of Thales), the occurrence of which suspended a battle between the Lydians and the Medes, he had been struck by the cogency of Mr. Baily's arguments, which showed that only a *total* eclipse could be admitted as sufficient to produce the effect ascribed to it; and by the remark (cited by Mr. Baily) of Maclaurin and Lemonnier, that in an annular eclipse of the sun, even educated astronomers when viewing the sun (nearly covered by the moon,) with the naked eye could not tell that it was not full. The appearances, however, in a total eclipse, as he should afterwards mention, were so striking, that there could be no difficulty in believing the historian's account to be literally correct.

Proceeding first to explain the simple causes of a solar eclipse, the Lecturer remarked that the moon's distance from the earth is nearly one four-hundredth part of the sun's distance, and that the moon's diameter is very nearly one four-hundredth part of the sun's diameter, and that therefore, on the average, the sun's *apparent* diameter and the moon's *apparent* diameter are very nearly equal. But in consequence of the elliptic forms of their orbits, the sun's

distance is liable to small variations, and the moon's distance to very considerable variations: when the moon is at the most distant part of her orbit, her *apparent* diameter is smaller than the sun's, and if she happens at that time to be between a spectator and the sun, she will be seen as a black disk covering the central part of the sun and leaving a ring of light all round: when the moon is at the nearest part of her orbit, her *apparent* diameter is larger than the sun's, and she will, to a spectator in the proper locality, completely cover the sun, and produce a Total Eclipse. But neither of these things can happen unless the plane of the moon's orbit be in such a position that the moon, when approaching the state of conjunction or new moon, is seen to pass not above the sun or below the sun but over the sun.

The Lecturer then called attention to the circumstance that four successive total eclipses occur in the month of July at intervals of nine years, namely 1833, July 17; 1842, July 8; 1851, July 28; and 1860, July 18. For the explanation of this curious circumstance it was necessary to show, first, how it happened that at intervals of nine years the moon's orbit was in such a position that, for a nearly definite apparent position of the sun, the moon's path would cross the sun's disk: secondly, how it happened that at intervals of nine years the moon was at nearly her smallest distance from the earth, so that her apparent diameter was larger than the sun's. In reference to the former, it was shown that the moon revolves in an orbit whose plane is inclined to the plane of the ecliptic (the *apparent* orbit of the sun round the earth), and that the inclination is nearly invariable, but that the position of the line in which the plane of the moon's orbit intersects that of the ecliptic is constantly changing, revolving steadily in the direction opposite to the moon's motion, and performing a complete revolution in something more than nineteen years. Therefore if one node or extremity of this line of intersection were directed nearly to the July sun in 1833, the opposite node would be directed nearly to the July sun in 1842, and so on for four successive periods of nine years; and eclipses would be possible in July at the end of each period. But to show that they might be total eclipses, it was necessary to remark that the moon revolves in an ellipse of which the earth occupies one focus (a point much nearer to one end than to the other) and that the position of this ellipse is constantly varying, its long axis turning round in the same direction as the moon's motion, and completing a revolution in nine years and a half. Therefore if in 1833 the shorter end of the ellipse were nearly turned to the July sun, in 1842 the axis of the ellipse would have completely revolved, so that the shorter end of the ellipse would again be nearly turned to the July sun: and thus the eclipse which occurred, if total in 1833, would, if central, be total (not annular) in 1842; and so on for four periods of nine years.

The Lecturer then called attention to the great difference in the directions of the shadow-paths across Europe, for the eclipses of 1842

and 1851: (the former being from W. S. W. to E. N. E. nearly, the latter from N. W. to S. E. nearly). This arose in part from the circumstance that (as above explained) the former of these eclipses occurred when the node or end of the intersection-line of the planes of orbits, turned towards the July sun, was that at which the moon rises to the north of the ecliptic, the latter when it is that at which the moon is descending to the south of the ecliptic. But the principal cause of the difference is this; that the former eclipse occurred early in the morning, the latter in the afternoon: on placing a terrestrial globe in the proper position for July, with its north pole inclined considerably towards the sun, it is seen that, even if the moon moved precisely in the ecliptic, the path of her shadow across Europe before Europe came to the meridian would trend from the south to the north; but if Europe had passed the meridian it would trend from the north to the south.

Quitting the geometrical explanations, the Lecturer then proceeded to describe some peculiar phænomena which had been observed in eclipses, and first, one which had been observed most distinctly in annular eclipses, and which is known by the name of "Baily's beads and strings." When the preceding limb of the moon, traversing the sun's disk, approaches very near the sun's limb, or when the following limb of the moon is in the act of separating from the sun's limb to enter on the sun's disk, the two limbs are joined for a time — (no one has estimated the duration with accuracy) — by alternations of black and white points or strings. Phænomena, evidently of the same class, have been observed in the transits of Venus and Mercury over the sun's disk; the black planet, when just lodged on the sun's disk, being pear-shaped, with its point attached to the black sky. The Lecturer was able to state, in his own experience at the Royal Observatory, that at the same transit of Mercury this phænomenon was seen with some telescopes and was not seen with others. In the annular eclipse of 1836 observed at Königsberg, where the moon's limb but just entered completely on the sun's, and where consequently it grazed along the sun's for many seconds of time, the phænomenon appeared to resolve itself simply into points of light seen between lunar mountains. The Lecturer expressed himself generally satisfied with Professor Powell's explanation, that the phænomenon originates in that inevitable fault of telescopes and of the nervous system of the eye which tends to extend the images of luminous objects (producing what is generally termed irradiation), and thus enlarges the sun's disk towards the sky, towards the moon or planet, and towards the bottoms of its hollows.

In describing the total eclipse of 1842 (which perhaps was better observed than any one preceding it) the Lecturer insisted on our obligation to M. Arago, who had prepared the preliminary notices, and had used his powerful personal influence in inducing persons to make observations at numerous stations in the south of France; and had afterwards collected and compared the observations. Besides these

French observations, and the observations made by astronomers officially located in the path of the shadow, we have the observations of M. Schumacher who went to Vienna, of MM. Otto Struve and Schidlowsky at Lipetsk, (the former of whom was sent expressly by the Russian government,) of Mr. Baily who went to Pavia, and of the Lecturer himself who went to the Superga (near Turin).

It appears that, with M. Arago's telescope, the whole circumference of the moon was visible when the moon had entered on only about two-thirds of the sun's diameter. Whatever may be the cause of this unusual appearance, it seems to require the use of a telescope with a small number of glasses in the highest state of polish.

As the totality approached, a strange fluctuation of light was seen by M. Arago and others upon the walls and the ground, so striking that in some places children ran after it and tried to catch it with their hands.

Of the awful effect of the totality, and of the suddenness with which it came on, it is difficult to give an idea. The Lecturer cited an expression from Dr. Stukely's account of the total eclipse of 1744, observed on a cloudy day, "that the darkness came dropping like a mantle:" and compared it with his own, in similar weather, "that the clouds seemed to be descending." But all agree in the description of livid countenances, indistinct and sometimes invisible horizon, and general horror of appearance. It is well that we are enabled, by means of instances collected by M. Arago, to show that these are not simply the inventions of active human imaginations. In one case, a half-starved dog, who was voraciously devouring some food, dropped it from his mouth when the darkness came on. In another, a swarm of ants, who were busily carrying their burdens, stopped when the darkness came on and remained motionless till the light reappeared. In another, a herd of oxen, as soon as the totality was formed, collected themselves into a circle and stood with their horns outwards. Some plants (as the convolvulus and silk-tree acacia) closed their leaves.

The darkness at Venice was so great that the smoke of the steamboats could not be seen. In several places, birds flew against houses, &c. Where the sky was clear, several stars were seen. In several places a reddish light was seen near the horizon. A heavy dew was formed at Perpignan.

The Lecturer cited an instance which had been related to him by M. Arago, in which the Captain of a French ship had beforehand arranged in the most careful way the observations to be made: but, when the darkness came on, discipline of every kind failed, every person's attention being irresistibly attracted to the striking appearances of the moment, and some of the most critical observations were thus lost.

The most remarkable phænomenon observed in all preceding total eclipses, and seen equally in this, is the ring of light surrounding the moon, called the *corona*. The Lecturer described the magical

change, from the state of a very narrow lune of solar light (the contour of the moon being totally invisible,) to the state of an entire dark moon surrounded by a ring of faint light, as most curious and striking. The progress of the formation of the ring was seen by his companion, and by some other persons: it commenced on the side of the moon opposite to that at which the sun disappeared. In the general decay and disease which seemed to oppress all nature, the moon and corona appeared almost like a local disease in that part of the sky. In some places, the corona was seen as distinctly double; it would appear that the ring which the Lecturer saw (whose breadth, by estimate of repeated duplication, he found to be about one-eighth part of the moon's diameter, or four minutes of arc nearly) was the inner of the two rings seen by M. Arago and others. The texture of the corona appeared in some places as if fibrous, or composed of entangled thread; in some places, brushes or feathers of light proceeded from it. One photometric estimate of the quantity of light in the corona, cited by M. Arago, gave it equal to one-seventh part of full moonlight. From a chromatic analysis of its light by means of an ordinary prism, it appeared to be deficient in green rays.

The Lecturer characterised the inquiry into the origin and locality of this corona as one of the most interesting connected with the eclipse. It had been specially indicated by M. Arago (see the Annuaire du Bureau des Longitudes, 1842) as a very important subject of inquiry whether the corona is concentric with the moon or with the sun; but his recommendation had received very limited attention. The general tenor of the evidence went to prove that the corona belongs to the sun. This, however, was not the opinion of more ancient writers, who tacitly consider it as the atmosphere of the moon.

But the most remarkable of all the appearances were the red mountains or flames apparently projecting from the circumference of the moon into the inner ring of the corona, to the height of one minute of arc at the smallest estimation, or a much greater height by other estimations. It was afterwards discovered that these had been seen before by Vassenius, a Swedish astronomer, who observed the eclipse of 1733 at Göteborg, (a place very favourable for the approaching eclipse), and whose account is given in the Philosophical Transactions, vol. xxxviii. He terms them "subrubicundæ nonnullæ maculæ, extra peripheriam disci lunaris conspectæ, numero tres aut quatuor." This observation, however, was not known to any of the observers in 1842, and all were therefore taken by surprise. Drawings were exhibited of these red mountains as seen at Perpignan, Narbonne, Vienna, Pavia, Superga, and Lipetsk. It was shown that, by a trace still visible on the engraving, the drawing first made at Vienna had coincided very exactly with that made at Pavia; that the Narbonne observations would be very exactly reconciled with them by supposing the error (very likely to occur to unpractised astronomers) of

taking the north limb to be the upper limb; that at Perpignan, Superga, Lipetsk, the lowest of the red prominences was not seen: and that at Superga and Lipetsk only was the middle one of the upper prominences seen, though in several places an irregular band of red light had been seen of which one salient point might be the prominence in question. In all the places where the order of formation had been observed, the same prominence (the left-hand upper prominence) was defined as the first seen. At Perpignan this was observed by M. Mauvais to show itself first as a small point and to project gradually as from behind the moon. The discordance in these representations did not appear to the Lecturer at all startling; it was not greater than the discordance in the accounts given by two good observers in different rooms of the same building at Padua.

The determination of the locality and nature of these red prominences is one of the most difficult of all connected with the eclipse. The first impression undoubtedly was that they are parts of the sun. If so, their height, at the lowest estimation, is about thirty thousand miles. The principal objection, however, to their solar location is the difference in their forms as seen at different places: thus at Perpignan they are represented as widest at the top: at all other places they are widest at the base. Moreover at some places, as Pavia and Vienna, where they were seen a long time, they underwent no change: whereas at Perpignan one at least was seen to slide out as from behind the moon. In all cases, however, much is to be allowed for the hurried nature of the observation.

The only theory which has been formally propounded as explaining them is that of M. Faye, who conceives them to be the result of a kind of mirage.

The Lecturer explained the nature of ordinary mirage (the kind of reflection produced by the hot air adhering to a heated surface of any solid) and described the distortion produced in the image of a star as seen in the Northumberland telescope of the Cambridge Observatory, when first mounted in a square pyramidal tube, whose angles were constructed more solidly than its sides, reducing the inner form to an octagon. When this tube had become warm before observation in the open air, the angle-blocks remained warm after the sides and the internal air had become cool, and a kind of mirage was produced which distorted the image of a star into four long rays like the sails of a windmill. M. Faye has particularly adverted to this instance, and conceived that in the circumstances of our atmosphere at the time of the eclipse, where the air on one side only of the path of light is somewhat heated by the sun, sufficient explanation might be found for the distortion of some inequalities of the moon. The Lecturer professed himself totally unable to follow this theory into details, remarking only that in the rapid passage of the moon's shadow he conceived it impossible to find air in the state required for the explanation.

The Lecturer then adverted to that part of his subject of which

all that had been already said was only introductory, namely the approaching eclipse of July 28. After quoting an American newspaper, showing the great interest excited by this eclipse beyond the Atlantic as one of the strongest inducements for Americans to visit Europe in the coming summer, he invited attention to its course across Europe. Entering Norway near Bergen, the shadow crosses both coasts of Norway, both coasts of Sweden, and the eastern coast of the Baltic: then ranges through Poland and the south frontier of Russia across the sea of Azof through Georgia to the Caspian Sea. It passes Christiania, Göteborg, Carlscrona, Danzig, Königsberg, Warsaw, and Tiflis. A great part of this course, especially that from Bergen to Königsberg, is very accessible by sea, and Warsaw by land. The Lecturer trusted that many English travellers might be induced to observe this eclipse. If possible, stations should be chosen as well near the northern and southern boundaries of the shadow as near the centre. No particular skill in astronomical observation is required, the phænomena being rather of a more generally physical kind: and indeed, as far as the observations of the eclipse of 1842 showed, the travelling physicists had been more successful than the stationary astronomers. The apparatus required would depend on the special objects of the observer; a telescope and a watch might be considered indispensable in every case: for analysis of light, a common prism and a polariscope might be taken by some persons: photometry, actinometry, &c., might be interesting to others, and appropriate instruments would be required: other observers would be interested in meteorology. The apparatus which the Lecturer considered it most important to perfectionate now, for use during the eclipse, is photogenic apparatus; it would be impossible to set too high a value on a series of Daguerréotypes or Talbotypes of the sun and corona taken during the eclipse.

The Lecturer concluded by saying that a series of suggestions for the observation, accompanied by a map, had been prepared by a Committee of which he is a member, and were nearly ready to leave the printer's hands: and he undertook to transmit a copy of these suggestions to any person who would make application to him.

G. B. A.

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In the Library were exhibited:—

Apparatus to illustrate the Pendulum Experiment [by Mr. Bishop].
Improved Orrery [by Messrs. Newtons].
"Towers and Spires of England"—the original drawings [by C. Wickes, Esq.]
Hindu Mythological Paintings [by the United Service Institution].

## GENERAL MONTHLY MEETING,

Monday, May 5.

WILLIAM POLE, ESQ., M.A., F.R.S., Treasurer and Vice-President, in the Chair.

The Secretary announced that the President had nominated the following Vice-Presidents for the ensuing year:—

William Pole, Esq., Treasurer R.I.
Sir John P. Boileau, Bt.
W. R. Hamilton, Esq.
Rt. Hon. T. B. Macaulay.
The Lord Overstone.
Professor Wheatstone.

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Admiral Sir George Sartorius, R.N.
was *admitted* a Member of the Royal Institution.

Wm. Ashton, Esq.
George Chenevix, Esq.
George J. Eyre, Esq.
John Fergus, Esq., M.P.
Alfred Hooper, Esq.
The Lord Lovaine.
Hon. Henry A. Murray, Capt. R.N.
Miss F. S. Solly.
Wm. Raikes Timins, Esq.

were duly *elected* Members of the Royal Institution.

William Thos. Brande, Esq. F.R.S L. & E. &c. was re-elected as Professor of Chemistry in the Royal Institution.

The following PRESENTS were announced, and the thanks of the Members ordered to be returned for the same;—

FROM

*G. J. Guthrie, Esq., F.R.S.*—Plans and Sections of the Several Lines of Railway in Ireland laid out under the direction of the Commissioners. fol. 1837.

*The Royal Geographical Society*—Journal, Vol. XX. Part II. 8vo. 1851.

*Thos. Fisher, Esq.* (*the Author*)—Dial of the Seasons; or a Portraiture of Nature. 12mo. Chart to Ditto (*on Roller*) Philadelphia. 1845.

*Edward Thornton, Esq. M.R.I.* (*the Author*)—The History of the British Empire in India. 6 Vols. 8vo. 1851.

*The Hon. East India Company*—Magnetical and Meteorological Observations made at Bombay in 1846. 4to. 1849.
Magnetical Observations in 1847, Part I. 4to. 1850.

*The Commissioners in Lunacy*—Reports to the Lord Chancellor, 1844 to 1850.

*W. R. Hamilton, Esq. F.R.S. M.R.I. &c.*—Bibliotheca Grenvilliana; or Bibliographical Notices of Rare and Curious Books forming part of the Library of the Right Hon. Thos. Grenville, by J. T. Payne and Henry Foss. 3 Vols. 8vo. 1842.

*M. Faraday Esq. Full. Prof. Chem. R.I.*—Relations des Expériences pour déterminer les principales Lois Physiques et les Données numériques qui entrent dans le calcul des Machines à Vapeur, par M. V. Regnault. Partie I. 4to. Paris. 1847.

Mémoires présentés par Divers Savants à l'Académie des Sciences de l'Institut de France. Tome IX. 4to. Paris, 1846.

Monatsbericht der Königl. Preuss. Akademie der Wissenschaften zu Berlin. Feb. 1851. 8vo.

*The Royal Society of Van Dieman's Land*—Papers and Proceedings, Vol. I. Part II. 8vo. 1850.

*The Royal Astronomical Society*—Monthly Notices, Vol. XI. Nos. 1—4. 8vo. 1850-1.

*Commander Inglefield, R.N. M.R.I. (the Author)*—A New Theory of Terrestrial Magnetism, &c. 8vo. 1851.

*The American Philosophical Society*—Proceedings, No. 45. 8vo. 1850.

*Rev. W. W. Ellis, M.A. (the Author)*—Ten Lectures on Romanism, Tractarianism, etc. 12mo. 1851.

*James Yearsley, M.R.C.S., M.R.I. (the Author)*—A New Mode of Treating Deafness. 12mo. 1850.

Elongated Uvula and other Morbid Conditions of the Throat, &c. 8vo. 1851.

Deafness practically illustrated. 12mo. 1850.

*The Institution of Civil Engineers*—Transactions, Vol. III. Parts 2—5. 1840-2. 4to.

Minutes of Proceeding for 1837, 1840, 1841, 1844, 1845, 1846, 1847, and parts of 1848, 1849, 1850. 8vo.

Do. for April, 1851. 8vo.

Catalogue of the Library of the Institution of Civil Engineers. 8vo. 1851.

List of Members, Dec. 1850. 8vo.

*The Royal Society of Edinburgh*—Proceedings, No. 33, 34. 8vo. 1848-9.

*The Royal Institute of British Architects*—Proceedings, April, 1851. 4to.

*The Horticultural Society of London*—Journal, Vol. VI. No. 2. 8vo. 1851.

*The Royal Irish Academy*—Proceedings, Vol. IV. Part III. 8vo. 1850.

*J. C. David, Esq. (the Author)* Geographical Botany and Astronomy, &c. 4to. 1850.

The Hebrew Alphabet, a Key to the Divine and Universal Language, 1842.

*Jacob Bell, Esq. (the Editor)*—The Pharmaceutical Journal for May, 1851.

*Reginald Stuart Poole, Esq. (the Author)*—Horæ Ægyptiacæ: or, the Chronology of Ancient Egypt. 8vo. 1851.

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## WEEKLY EVENING MEETING,

Friday, May 9.

The Duke of Northumberland, President,

in the Chair.

The Rev. Baden Powell, M.A. F.R.S. F.R.A.S. F.G.S.

SAVILLIAN PROFESSOR OF GEOMETRY IN THE UNIVERSITY OF OXFORD.

### *On the Recent Experiment showing the Rotation of the Earth by means of the Pendulum.*

The experiment alluded to has been the subject of so much popular notice at the present time that it would be needless to go into a particular description of its nature or object. If fully verified, the

result would however hardly amount to any more *palpable* proof to the *senses* than other astronomical phenomena afford; in this case, as well as in those, the conclusion is equally derived from *reasoning* on the actual appearances.

An idea of such an effect seems to have occurred long ago, and is mentioned in a paper in the Phil. Trans. 1742, No. 468, by the Marquis de Poli, in the course of some observations on the pendulum of a different kind. He remarks, "I then considered (adopting the hypothesis of the Earth's motion) that in one oscillation of the pendulum there would not be described from its centre perfectly one and the same arc in the same plane:"— but he does not pursue the subject, as being foreign to his immediate object.

It appears also (see Comptes Rendus, 1851, No. 6) that in 1837 Poisson had hinted at such an effect, but supposed it of insensible amount.

To some minds difficulties present themselves in the first instance, which are easily removed by a few simple illustrations. In the first place the deviation from parallelism to itself, of the meridian of any place, during the rotation of the Earth, is a simple geometrical question easily determined, and the inclination expressed by a trigonometrical formula. In the next place the independence of the motion of the pendulum, notwithstanding that the point of support is carried along with the earth in its rotation, and that the whole seems to form a part of the earth, is a point easily elucidated by very simple experiments, in which the vibration of a small pendulum is seen to continue parallel to itself notwithstanding a motion given to the point of support; the effect being in fact only a simple consequence of the coexistence of two motions communicated to a body at the same time. A beautiful apparatus, lent by Mr Bishop for showing this, was exhibited on the present occasion.

The experiment originally made by M. Foucault was repeated and confirmed under the inspection of M. Arago, and other eminent scientific men with all due precautions in Paris, as also at Ghent, Brussels, and elsewhere. In England besides the public repetitions at the Russell, London, and Polytechnic Institutions, by Dr. Roget, Mr. Bishop, and Mr. Bass, the experiment has been tried at York by Professor Phillips, and at Bristol by Mr. Bunt, with careful attention to all the circumstances likely to ensure the avoidance of sources of error, and to secure precise results. At the Royal Institution on the present occasion the experiment was exhibited under two modifications by Dr. Bence Jones and by Mr. Bass. Other observers have also repeated it in various places, especially at Dublin, where Messrs. Haughton and Galbraith, Fellows of Trinity College, have pursued the research with all imaginable precautions, and have obtained results somewhat different from those of other observers. According to nearly all the other experiments the rate of deviation continued uniform: according to Messrs. Haughton and Galbraith, it varied: and they seem to have been the only observers who have

watched through a complete revolution, the time of which was observed to be 28h. 26m.

The sources of probable error are numerous and not easy to be effectually guarded against. The most formidable, perhaps, is the extreme difficulty of causing the pendulum to vibrate truly in one plane, and to prevent its motion in a narrow ellipse. When this takes place, and the arc is considerable, the direction of the major axis is continually changing, owing to a well known mechanical cause (see Herschel's Outlines of Astronomy, p. 444); but this deviation is always in the same direction as that of the original motion of the pendulum, and consequently changes when that direction is changed. The true deviation may be distinguished from this, in that it is always from E. to W., independently of the direction of the original impulse; and the ball always passes accurately through the centre in every oscillation, whereas in the former case it never does.

For great accuracy, a variety of other precautions are requisite, as to the perfect freedom of suspension, guarding against currents, &c.; It is, however, possible that the elliptic deviation may oppose that due to the earth's rotation, while the latter may manifest itself in spite of the former.

It is extremely probable that many of the public repetitions may have been affected bythese causes of error; yet some of those referred to have been made by men of so much eminence and experience as observers, as to render it highly improbable that they should not have been sufficiently guarded against every source of fallacy. The accordance of many of the results at different places within fair limits of error, is also a strong argument in favour of their accuracy and trustworthiness.

The rates of deviation for one hour as determined at different places do not seem to be more discrepant than would accord generally with the differences of latitude. The experiment at Paris gave about 11° 30′, at Bristol 11° 42′, at Dublin rather more than 12°, at York about 13°.

To apprehend the theoretical principle it is necessary to take into account, 1st, the simple inclination of two successive positions of the meridian of a place to each other after any interval of time: 2nd, the independence of the motion of the ball of the pendulum, of the rotation of the point of support: and, 3rdly, that the ball, though free in this sense, is not however wholly free, being continually drawn down by gravity in a direction *continually changing* (relatively to the original direction of vibration,) as the earth revolves. Hence, though from the second cause the ball would have a tendency always to preserve a motion parallel to its original motion, and thus to deviate regularly from the meridian, it will (from the third cause) not preserve this exact parallelism, but will take an intermediate direction. The exact determination of this direction cannot be made on any general considerations, but must be the result of detailed mathematical investigation.

Thus in general in any illustrative or analogous case, so long as the *axis* of vibration continues parallel to itself, the *arc* of vibration will continue parallel to itself; but if the *axis* do not continue parallel, the direction of the arc of vibration will *deviate*. This distinction has been laid down and illustrated experimentally, by Mr. Wheatstone.

The investigation as pursued by M. Binet (Comptes Rendus, 1851, No. 6-7,) as well as by other mathematicians, is primarily founded on the method long since proposed by Euler, of resolving the rotatory motion of one point on the earth's surface into two, one about the vertical of that point, the other about an axis at right angles to it: of which the latter is the part effective in determining the direction of gravity on the pendulum, and is proportional to the sine of the latitude of the point.

M. Binet makes this general theorem the foundation of an analytical investigation, in which the conditions of the motion of the pendulum generally are expressed by certain differential equations, the integration of which conducts him to certain expressions, which when simplified by the consideration of limiting the vibration to small arcs, gives the azimuthal velocity uniform in the direction from E. to W. and in a simple proportion to the sine of the latitude: giving therefore the deviation for one hour in the latitude of Paris about $11\frac{1}{2}°$ and the time of a complete revolution $32^h\ 8^m$. An investigation has also been made independently by the Astronomer Royal, leading to very nearly the same result.

Other mathematical solutions have also been proposed by Dr. Day of Bristol, and by Mr. J. R. Young (late Professor of Mathematics at Belfast). The latter gentleman has obtained as a consequence of his investigations one remarkable result, which he states thus:

"The arc of the circular rim of the *table* subtended by the angle of deviation at its centre, is always (in one revolution of the earth) exactly equal to the difference in *length* of the two parallels of latitude described by the *centre* and *extremity* of the meridional diameter of the table." [See Mechanic's Mag. May 3rd & 10th, 1851.]

The lucid and able illustrations of the subject given by Professor Sylvester have thrown much light on the explanation.

Modifications of the principle have been suggested by M. Chasles, on the idea of the difference of rotatory velocity between any two points on the same meridian, which difference, insensible as it might seem to be for the minute length of a vibration, he shows, will in successive vibrations become sensible. This idea is nearly the same as that announced by Laplace (Mécanique Céleste, vol. iv. c. 5.), who infers a deviation in the plane of a projectile fired in the direction of the meridian. The same idea has been discussed also by other mathematicians: and has been further carried out by M. Poinsot who has suggested, that if two balls suspended by separate strings, hanging together in contact, and consequently both partaking in

the velocity of rotation of that point of the earth, were to be suddenly separated by releasing a spring placed between them, and at first confined by a string, they would then show the difference of velocity, belonging to points on the earth at that distance apart, and would consequently revolve round the vertical. (See Comptes Rendus, 1851, No. 14.)

A beautiful variation of the experiment has been suggested by Mr. Bravais (Comptes Rendus, 1851, No. 6.) in which a *perfectly* circular motion is communicated to a pendulum (by a peculiarly ingenious contrivance) the time of whose revolution will be different according as its direction conspires with or opposes that of the earth.

If all *torsion* in the thread could be got rid of, a ball simply suspended and furnished with an index in its equator would be seen to rotate. But the torsion destroys the effect. This is the suggestion of M. Baudrimont (Comptes Rendus, 1851, No. 8.)

But by far the most complete idea not only of the general principle, but of the precise law of the sine of the latitude, is obtained from the beautiful apparatus constructed by Mr. Wheatstone, in which the pendulum is replaced by the vibrations of a coiled spring, the axis of which can be placed in any required inclination or *latitude* with respect to a vertical semicircular frame, which is made to revolve about its vertical radius, and the direction of the vibrations is seen to change in a degree proportioned to the sine of the latitude or inclination; as for example for lat. 30 the sine $= \frac{1}{2}$: and consequently if the vibration be originally in the meridian, when the meridian has revolved 180°, the deviation $= 180° \times \frac{1}{2} = 90°$ or is at right angles to the meridian.

This apparatus was exhibited at the lecture.

Upon the whole the experiment is one of high interest and importance: some discrepancies or difficulties in the different views taken of the theory as well as in the observed results, seem to indicate that the subject, however apparently simple, has not yet been thoroughly worked out, — and to point to the desirableness of further repetitions of the experiments, if possible *in vacuo*, and with increased precautions, as well as to a revision of the dynamical and analytical processes, by which possibly any seeming difficulties may be cleared up.

B. P.

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In the Library were exhibited :—

Silver chased Sword-hilt, dated 1642, containing ten Portraits, Frederick William, Stadtholder of Holland, and his Court.

The Mouse-deer and the Guanna, mounted by Messrs. Leadbeater.

Two inlaid Derbyshire Tazzas, &c. [by Mr. Tennant].

Lithographed Fac-Similes [by Messrs. Ashbee and Tuckett].

Figures in Coloured Biscuit, soft-metal bronzed, and Serpentine stone [by Messrs Cundall and Addey].

Silver-gilt Shield—" Boadicea " [by Messrs. Hunt and Roskell].

[FOR THE USE OF MEMBERS.]

# Royal Institution of Great Britain.

1851.

## WEEKLY EVENING MEETING,

Friday, May 16.

THE LORD OVERSTONE, Vice President, in the Chair.

CAPTAIN W. H. SHIPPARD,

### *On Central America and the Ship-Canal.*

CAPTAIN Shippard commenced by alluding to the very great importance of communications, whether by canal or railway, through the Isthmuses of Suez and Darien. He then referred to the various modes proposed for traversing the latter, and stated what he conceived to be the advantages that would result from a ship-canal through Nicaragua, referring throughout his discourse to a Relief Model before him, furnishing the complete physical features of the country from the Port of Realejo on the Pacific, including the Lakes Leon and Nicaragua, down to the south of the Rio San Juan on the Atlantic, based upon the English, French, and Spanish Admiralty surveys, and upon French, Spanish, German, Dutch, and American authorities.

He then read a series of notes respecting the political character, geographical features, and natural history of Central America; and concluded by giving a historical sketch of the connexion between that country and the British Government, since the early part of the 17th century, by means of the Mosquito nation, the Governors of Jamaica, &c.

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### *Electric Currents in Plants.*

MR. FARADAY communicated a brief verbal notice of the results obtained by M. Becquerel in his recent researches into the nature and directions of the Electric currents which may, or do exist in the different parts of a tree or other plant; and also of those which exist in relation to the tree and the surrounding earth. By the insertion of terminals attached to the galvanometer into various parts of the tree, effects were obtained which indicated that the current is *from* both the bark and the heart-wood through the instrument *to* the cambium or parts *between* the bark and the wood. As regards the relation of the vegetative process to the atmosphere, the earth was found positive to the paren-

chyma, which was relatively negative. As the earth is relatively negative to the serene atmosphere above, it would appear that the vegetative process acts in a direction contrary to that of the causes which give the earth and air around it their relative electric states. (Vide *Annales de Chimie*, 1851, tome xxxi. p. 40.)

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In the Library were exhibited —

Maps and Views of Central America and Drawings of the Inhabitants, Antiquities, Animals, and Plants [by Capt. Shippard].

The Trogon Resplendens and other birds from Central America [by Messrs. Leadbeaters].

A small gold figure from Bogota — Models of a boat built for Capt. Parry's Polar Expedition, and a cutter by Mr. T. Roberts; an Indian Gun; Mocassins, &c. [by the United Service Institution].

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## WEEKLY EVENING MEETING,

Friday, May 23.

THE REV. JOHN BARLOW, M.A., F.R.S., Secretary R. I. in the Chair.

WILLIAM HOSKING, ESQ.

PROFESSOR OF ARCHITECTURE AND OF ENGINEERING CONSTRUCTIONS AT KING'S COLLEGE, LONDON.

### *On Ventilation by the Parlour Fire.*

THE term Ventilation does not strictly imply what we intend by its use in reference to Buildings used as dwelling-houses, or otherwise for the occupation of breathing creatures. To ventilate is defined "to fan with wind;" but one of the main objects for which houses and other enclosed buildings are made, is shelter *from* the wind, Inasmuch, however, as the wind is but air in motion, and we can only live in air, air may not be shut out of our houses, though, for comfort's sake, we refuse to admit it in the active state of wind. But in doing this — in shutting out the wind,— we are apt to put ourselves upon a short allowance of air, and to eke out the short allowance by using the same air over and over again.

There is a broad line of distinction, indeed, to be drawn between in-door and out-door ventilation; for although the principles upon which nature proceeds are the same, the operation is influenced by the circumstances under which the process may be carried on. Whether it be on the hill-side, open to the winds of heaven, or in a close room from which all draught of air is excluded, the expired

breath, as it leaves the nostrils heated by the fire in the lungs, rises, or seeks to rise, above their level, and may not be again inhaled. Out of doors the cooler or less heated air of the lower level presents itself for respiration unaffected by the spent exhaled air, but in a close apartment the whole body of included air must soon be affected by whatever process any portion of it may have undergone. The process by which Nature carries off spent air, purifies, and returns it uncontaminated, is thus checked by the circumstances under which we place ourselves within-doors. All our devices for shelter from the weather, and for domestic convenience and comfort, tend to prevent the process provided by Nature from taking effect according to the intention in that respect of the Creator. We not only confine ourselves, indeed, and pen up air in low and close rooms, but we introduce fire by which to warm the enclosed air; wanting light within our dwellings when daylight, fails, we introduce another sharer in the pent-up air of our rooms, being fire indeed in another form, but generally under such circumstances, that it not only abstracts from the quantity, but injures the quality of what may remain. But fire, whether in the animal system, in the grate, or in the lamp, cannot long endure the imagined limitation of air. There must be access of air — of vital air — by some channel or other, or the fire will go out.

An open fire in the grate must however have a vent for some of its results, or it will be so disagreeable a companion that its presence could not be endured, even as long as the most limited quantity of air would last; and the fire will compel the descent of air by the vent commonly supplied under the name of a flue — a chimney flue — to render its presence tolerable in a closed room, if a supply be not otherwise obtainable. But as the outer air at the higher level of the top of a chimney, because of the rarity of the air in and above the flue, responds to the demand of the fire less easily than the lower air, or that at and about the level of the fire; and the lower air, or air at the lower levels, forces its way in, therefore, by any opening it can find or make — through the joints of the flooring-boards and under the skirtings — the supply passing first up or down the hollow lathed and plastered partitions, sometimes even up from the drains; and through the joints under and about the doors and windows. If these channels do not exist, as they may not when the joiners' work and the plastering are good, or when the open joints referred to are stopped up by any means, the fire smokes, and every known means of curing the chimney failing, means are sought of obtaining heat without the offending fire. Ventilation is not thought of yet.

The open fire may be made to give place to the close stove or to hot air-pipes, to hot-water pipes, or to steam pipes—which make hot the air about them in a close room without causing draughts. But the warmth obtained in pipes is costly under any circumstances. Air does not take up heat freely, unless it be driven and made to pass

freely over the heated surface; and there being little or no consumption of air, and consequently little or no draught, in connexion with heated bodies, such as close stoves and hot pipes, the heat from them is not freely diffused, and is not wholesome. There is with all the expense no ventilation.

Stoves and hot pipes are, moreover, exceedingly dangerous inmates in respect of fire. Such things are the most frequent causes, directly or indirectly, of fires in buildings. Placed upon, or laid among or about the timbers and other wood-work of hollow floors, and hollow partitions, and in houses with wooden stairs, more conflagrations are occasioned by hot pipes and stoves, than by any thing else, and perhaps more than by all other things together.

Open stoves with in-draught of air warmed by being drawn quickly (when it is drawn quickly) over heated surfaces may be made part of a system of safe and wholesome in-door ventilation; but to be perfect there must be also out-draught with *power* to compel the exit of spent or otherwise unwholesome air. But the arrangements for and connected with such stoves are special and therefore costly, unless the buildings in which they may be employed have been adapted in building to receive them. An in-draught stove may however be applied with great advantage as it regards the general warmth and ventilation, in the lowest story of any house, if there be compelled out-draught at the highest level to which it will naturally direct itself if it be not retained, so that the in-draughted air, tempered as it enters, may be drawn out as it becomes spent, or otherwise contaminated.

But this must be considered in all endeavours to effect in-door ventilation, or the endeavour will fail. *The air must be acted upon, and not be left, or be expected, to act of itself, and to pass in or out as may be desired merely because ways of ingress and egress are made for it.* Make a fire in a room, or apply an air-pump to the room, and the outer air will respond to the power exerted by either by any course that may be open to it, and supply the place of that which may be consumed or ejected; but open a window in an otherwise close room and no air will enter; no air can enter, indeed, unless force be applied as with a bellows, whereby as much may be driven out as is driven in, with the effect only of diluting not of purifying. Even at that short season of the year in which windows may be freely opened, unless windows are so placed as to admit of the processes of out-door ventilation being carried on through them by a thorough draught from low levels to high levels, open windows are not sufficient to effect thorough in-door ventilation. There must for this purpose be in every room a way by which a draught can be obtained, and this draught must take effect upon the most impure air of the room, which is that of the highest level. The chimney opening may supply a way at a low level, and a draught may be established between it and the window, but the air removed from the room by such a draught is not neces-

sarily the spent or foul air. But make an opening into the chimney flue near the highest level in the room, that is to say, as near as may be to the ceiling, and if a draught be established between the window and the flue by this opening, the ventilation is complete; that is to say again, if there be draught enough in the chimney flue from any cause to induce an up-current through it, or if there be motion of the external air to drive the air in at the window and force an up-current through the flue.

Windows may not be put open in the long enduring colder season, however, and for the same reason in-draughts of the outer air by any other channel are offensive and injurious. To open a door for the sake of air is but a modification of opening a window, and, if the door be an internal one, with the effect of admitting already enclosed, and, probably, contaminated air. Means of efficient in-door ventilation, must therefore, be independent of windows and doors; and the means should be such as will lead to a result at once wholesome and agreeable.

Many plans have been suggested, and some have been carried into effect, of warming air, and then forcing it into or drawing it through buildings, and, in the process of doing so, removing the foul or spent air from the apartments to which it may be applied. Some of these plans are more and some are less available to wholesome and agreeable in-door ventilation, but even the best are rather adapted to large apartments, such as those of Hospitals, Churches, Theatres, and Assembly-Rooms, than to private dwelling-houses in which the rooms are small and labour and cost are to be economised.

Plans have been proposed, too, for the economical ventilation of dwelling-houses; but they seem to be all in a greater or less degree imperfect. Ways of access are provided in some cases for the outer air directly to the fire in every apartment, to feed the fire, and indirectly to ventilate the room; way of egress in addition to the chimney opening and the chimney flue being sometimes provided for the spent air of the room; sometimes, indeed, as before indicated, by an opening into the chimney flue near the ceiling. A direct in-draught of cold air is not agreeable, and it may be pernicious, but if the outer air become warm in its way to the inmates of the room, the objection to its directness ceases. If however the warmth is imparted to it with foulness, the process does not fulfil the condition as to wholesomeness, and this is the case, when the outer air is admitted at or near to the ceiling to take up warmth from the spent and heated atmosphere of the higher levels. Having undergone this process, it is not the fresh air that comes warmed to the inmates, but a mixture of fresh and foul air that cannot be agreeable to any inmate conscious of the nature of the compound.

The endeavour on the present occasion was to show how the familiar fire of an apartment may be made to fulfil all the conditions necessary

to obtain in-door ventilation, to the extent at least of the apartment in which the fire may be maintained, and while it is maintained.

A fire in an ordinary grate establishes a draught in the flue over it with power according to its own intensity, and it acts with the same effect, at least, upon the air within its reach, for the means which enable it to establish and keep up the draught in the flue. The fire necessarily heats the grate in which it is kept up, and the materials of which grates are composed being necessarily incombustible, and being also ready recipients and conductors of heat, they will impart heat to whatever may be brought into contact with them.

It is supposed that the case containing the body of the grate is set on an iron or stone hearth in the chimney recess, free of the sides and back except as to the joints in front. Let all communication between the chamber so formed about the back and sides of the grate and the chimney flue be shut off by an iron plate, open only for the register flap or valve over the fire itself. External air is to be admitted to the closed chambers thus obtained about the grate by a tube or channel leading through the nearest and most convenient outer wall of the building and between the joists of the floor of the room, to and under the outer hearth or slab before the fire, and so to and under the back hearth in which sufficient holes may be made to allow the air entering by the tube or channel to rise into the chamber about the fire-box or grate. Openings taking any form that may be agreeable are to be made through the cheeks of the grate into the air-chamber at the level of the hearth. In this manner will be provided a free inlet for the outer air to the fire-place and to the fire, and of the facility so provided the fire will readily avail itself to the abolition of all illicit draughts. But the air in passing through the air chamber in its way to the fire which draws it, is drawn over the heated surfaces of the grate and it thus becomes warmed, and in that condition it reaches the apartment.

An upright metal plate set up behind the openings through cheeks of the grate, but clear of them, will bend the current of warmed air in its passage through the inlet holes, and thus compel the fire to allow what is not necessary to it to pass into the room; and if the opening over the fire to the flue be reduced to the real want of the fire, the consumption of air by the fire will not be so great as may be supposed, and there will remain a supply of tempered air waiting only an inducement to enter for the use of the inmates of the apartment. An opening directly from the room into the flue upon which the fire is acting with a draught more or less strong, at a high level in the room, will afford this inducement; it will allow the draught in the flue to act upon the heated and spent air under the ceiling, and draw it off; and in doing so will induce a flow of the fresh and tempered air from about the body of the grate into the room.

The mode thus indicated of increasing the effect of the familiar fire,

and making it subservient to the important function of free and wholesome ventilation, is not to be taken as a mere suggestion, and now for the first time made. It has been in effective operation for six or seven years, and is found to answer well with the simple appliances referred to. But it is the mode and the principle of action that it is desired to recommend, and not the appliances, since persons more skilled in mechanical contrivances than the author professes to be, may probably be able to devise others better adapted to the purpose.*

The mode referred to of warming and ventilating apartments by their own fires is most easy of application, and in houses of all kinds, great and small, old and new, and as the warmth derived from the fire in any case, comes directly by the in-draughted air, as well as by radiation of heat into the air of the apartment, fuel is economized. If the register flap be made to open and shut, by any means which give easy command over it, so that it may be opened more or less according to the occasion, and this be attended to, the economy will be assured; for it is quite unnecessary to leave the same space open over the fire after the steam and smoke arising from fresh fuel have been thrown off, as may be necessary immediately after coaling. The opening by theregister valve into the flue may be reduced when the smoke has been thrown off, so as to check the draught of air through the fire, and greatly to increase the draught by the upper opening into the flue, to the advantage of the ventilation and to the saving of fuel, while the heat from the incandescent fuel will be thereby rather increased than diminished.

Moreover the system being applicable in the cottage of the labourer, as fully and as easily as in the better appointed dwellings of those who need not economize so closely as labouring people are obliged to economize, the warmed air about the grate in a lower room may be conveyed directly from the air-chamber about the grate by a metal, or pot pipe, up the chimney flue, and be delivered in any upper room next to the same flue and requiring warmth and ventilation, the process of ventilation applied to the lower room being applicable to the upper room also.

The indicated means by which winter ventilation is obtained are not of course equally efficient in summer, for the draught of the fire is wanting; but the inlet at the low level for fresh air, and the outlet for the spent air at the upper level continuing always open, the heat which the flue will in most cases retain through the summer aided by that of the sun's rays upon the chimney top, secures a certain amount of up-draught, which is not without its effect upon the in-draught by the lower inlet even when windows and doors are shut.

While it is obvious that the air drawn into any house for the purpose of in-door ventilation need not be other than that which

* The appliances used by Mr. Hosking, will be found more fully described in his "Healthy Homes" published by Mr. Murray.

would enter by the windows of the same house, it may be unnecesary to enter into any inquiry as to the condition of the air heretofore spoken of as fresh and pure. "Fresh" and "pure" applied to air must be taken to mean the freshest and purest immediately obtainable, and that will be the same whether it be drawn in through a grated hole in a wall, or by a glazed opening close by it in the same wall. But it is a fair subject for inquiry whether,—speaking in London to Londoners,—the air about our houses in London is as pure,—or as free from impurity,— as it might be.

The out-door ventilation of large towns may be taken to be more complete above the tops of the houses and of their chimneys than it is or, perhaps, can be among and about the houses; — the processes of Nature are there not only unchecked, but are in fact aided by the heat thrown up by the chimneys into the upper air, and impurities which can be passed off by chimney flues, will be more certainly and more effectually removed and changed by Nature's chemistry, than if they are kept down to fester under foot and to exhale in our streets and about our doors and windows.

At this time every endeavour is made to provide for removing from our dwellings all excrementitious matter, and all soluble refuse, by drains into sewers, and so by the sewers to some outfall for discharge. The drain necessarily falls towards the sewer, and the sewer again to its outfall, and the sullage or soil drainage being rendered liquid thus passes in the usual course. But the usages and the necessities of civilized life cause a large proportion of the liquid refuse from dwelling-houses to pass off in a heated state, or to be followed by hot water arising from culinary processes, and from washing in all its varieties. The heat so entering the drains causes the evolution of fetid and noxious gases from the matters which go with, or have gone before, the hot water; and with these gases house-drains almost always, and sewers commonly, stand charged. They are light fluids and do not go down with the heavy liquid matters from which they have been evolved, but they seek to rise, and constantly do rise in almost every house through imperfections or derangements of the flaps and traps which are intended to keep them down, but which only, when they do act, compel some of the foul air to enter the sewers, and there to seek outlet to the upper air which they find by the gulley gratings in the streets.

It can hardly be said perhaps that *too much* attention has been given of late to the scour of sewers by water; but it is most certain that too little attention has been given to the considerations last stated, for nothing has been done to relieve the drains and sewers of their worst offence. The evolution of foul and noxious gases in the *drains* is certainly not prevented by scouring the *sewers*. In the mean time the poison exists underfoot, and exudes at every pregnable point within and about our houses, and it rises at every grating in our streets, though the senses may become dull to them by constant suffering.

Now this is an evil which can be greatly ameliorated, if it cannot indeed, be wholly cured; but it is by a process that to be effective must be general, and, therefore, it must be added, compulsory. The process is of familiar application in the ventilation of mines, and particularly of coal mines.—An up-cast shaft containing a common chimney flue carried up at the back of every house, and connected with the house-drains at their highest level would give vent to the foul air in the drains, and discharge it into the upper air.—The foul air evolved by heat expands, and expanding it rises, and rising it would be followed by cold air settling down by the gulley gratings in the streets, thus constituting their inlets downcast shafts, and the sewers and drains themselves channels for the currents setting to the up-cast shafts, by which they would be relieved. The down draught into the sewers would carry with it much soot and fine dust, which would settle upon the liquid current and pass off with it, and so remove some of the tangible as well as the intangible impurities, before referred to, from the air in our streets and about our houses.

Much in this way might be effected by the aid of causes in constant operation; but if the up-cast shaft to every house were also a fire-flue, or were only aided by the draught of a neighbouring fire, the up-current would be sufficient not only to prevent the house drains from retaining foul air, but the foul air would be thrown off into the upper air with better effect and be dissipated innocuously and without offence instead of steaming as it now does from the sewers into the air where it cannot be avoided. W. H.

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## *Artificial Production of the Ruby, &c.*

M. Ebelman of the Sèvre works near Paris being present with various specimens of the minerals which he has produced artificially; Mr. Faraday stated the process and results generally to the Members. The process consists in employing a solvent, which shall first dissolve the mineral or its constituents; and shall further, either upon its removal or a diminution of its dissolving powers, permit the mineral to aggregate in a crystalline condition. Such solvents are boracic acid, borax, phosphate of soda, phosphoric acid &c.:—the one chiefly employed by M. Ebelman is boracic acid. By putting together certain proportions of alumina and magnesia, with a little oxide of chrome or other colouring matter, and fused boracic acid, into a fit vessel, and enclosing that in another, so that the whole could be exposed to the high heat of a porcelain or other furnace, the materials became dissolved in the boracic acid; and then as the heat was continued the boracic acid evaporated, and the fixed materials were found combined and crystallized, and presenting true specimens of spinel. In this way crystals having the same form,

hardness, colour, specific gravity, composition, and effect on light as the true ruby, the cymophane, and other mineral bodies, were prepared, and were in fact identical with them. Chromates were made, the emerald and corundum crystallized, the peridot formed, and many combinations as yet unknown to mineralogists produced. Some of the crystals of spinel of recent production which M. Ebelman exhibited had facets the eighth of an inch or more on the sides. [Vide *Annales de Chimie*, 1848, tome xxii. p. 211 ] M. F.

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In the Library were exhibited :—

Cunningham's Patent Mode of Reefing Topsails [by H. Cunningham, Esq.].
Gage's Cataplasmes Galvaniques [by Dr. Bence Jones].
Specimens of Porphyritic Granite, from Fowey, Cornwall, worked by Mr. J. H. Meredith [by Mr. J. H. Meredith].
Stag-Candelabrum [by Messrs. Hunt and Roskell], &c. &c.

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## WEEKLY EVENING MEETING,

Friday, May 30.

The Duke of Northumberland, President in the Chair.

Colonel H. C. Rawlinson.

*A Few Words on Babylon and Nineveh.*

Referring to the interest which is now attached to the Assyrian Inscriptions, owing to the recent discoveries at Nineveh and Babylon, Colonel Rawlinson proposed to explain what Cuneiform writing was, how it had come to be deciphered, and what had been learnt from it.

Cuneiform characters did not belong to any particular language, or any particular alphabet, or even to any particular system of writing. The natives of Western Asia in antiquity made use generally of letters, formed for the convenience of sculpture with the arrow-head and wedge, instead of the curves and lines which have since become the standard elements of writing. Among such nations the Assyrians occupied the first place; then came the people of Susiana and Elymais and of Babylonia, and Chaldæa; and the series was terminated by the Armenians, the Scythians and the Persians. An alphabet consisting of nearly 400 signs, which had been perhaps originally a complete system of picture-writing, and in which to the latest period of its existencethe

ideographic or symbolic element continued to occupy a prominent place, served with unimportant modifications to express the languages of all these nations except the Scythians and Persians. This was called the First Class of Cuneiform writing.

The oldest form of it was the Assyrian, dating perhaps as early as 2500 B.C.; and in immediate connexion with that system, not only in regard to the forms of the letter, but more particularly as being applied to a language closely allied, if not identical, were the alphabets of Babylon and Chaldæa. The alphabets of Susa and Elymais, although in all probability superior in point of antiquity to the Babylonian and Chaldæan, were much further removed from the parent Assyrian type in regard to form, and were applied to languages of a total different family; while the Armenian again, the latest of all the Cuneiform alphabets of the first class, approached very closely in form and organization to the Assyrian, but was also used to express a language altogether distinct from any of the other dialects. The second class of Cuneiform writing derived like those of the first class from the Assyrian but more remotely and greatly simplified, was appropriated to the language of the aboriginal Scythic population of Central Persia; and the third class, in which the Cuneiform signs had been at length reduced to the representation of a regular literal and phonetic alphabet, was invented in the time of Cyrus the Great for the use of the inhabitants of Persia proper, who were then the dominant tribe in western Asia.

With regard to the languages expressed by these alphabets, Col. Rawlinson observed that the Assyrian, Babylonian, and Chaldæan were closely allied and constituted one of the earliest, if not *the* earliest of the Semitic dialects, of which any traces are now extant. The languages preserved in the Inscriptions of Susa, of Elymais, of Armenia, and in the centre column of the trilingual tablets of Persia, belonged to the Tartar or Allophylian family; and the Persian closely resembled the Vedic Sanscrit.

After explaining at what periods the different alphabets were used, who were the nations using them, and where the monuments, revealing to us these records of the early world, have been discovered, Colonel Rawlinson proceeded to explain and practically to illustrate the process of decipherment.

Copies of two Persian Cuneiform Inscriptions were exhibited which had been found at Hamadan (the ancient Ecbatana) and had supplied the first elements of decipherment. It was shown that these inscriptions were identical, with the exception of certain groupes; and it was further pointed out that the position of the groupes thus individualized naturally suggested the idea of proper names and indicated a succession of three generations. Historical testimony authorized the attribution of the monument in question to the line of kings who succeeded Cyrus the Great, and the names accordingly of Hystaspes, Darius, and Xerxes were applied at hazard to

the Cuneiform groupes, the result being, as these were actually the true names recorded, that twelve correct phonetic values were thus determined on the first essay at decipherment.

The alphabet was subsequently completed by a dissection of fresh materials, such as the genealogy of Darius preserved at Behistun, an enumeration of the Satrapies of the Persian Empire, several well ascertained titles, and more particularly a series of grammatical inflexions and terminations which were elaborated by a careful analysis and identified with their Sanscrit correspondents. Simultaneously with the progress thus effected in alphabetical decipherment, a general knowledge was obtained of the Persian language, a supply of materials, not less valuable for philology than for history, being furnished by the great inscription of Behistun recording the autobiography of Darius Hystaspes, which notwithstanding its inaccessible position on the face of a precipice at an elevation of four or five hundred feet from the plain, Colonel Rawlinson succeeded in copying.

The next step was to render the knowledge thus obtained in the simplest branch of Cuneiform science available for the examination of the more difficult. It had been fortunately the custom of the Achæmenian kings to append to their vernacular records translations in the Scythian and Babylonian Languages, and it was certain therefore, as the Persian tongue was now thoroughly understood, that if their trilingual records were sufficiently extensive, the Babylonian language could be deciphered and rendered generally intelligible through the Persian key. To this task accordingly Colonel Rawlinson had devoted himself; but owing to the extreme difficulty and complexity of the Babylonian system of writing, (ideographic and phonetic signs being intermingled, and the phonetic signs bearing often several distinct syllabic values), and more especially owing to a defectiveness of materials, for a small portion only of the Babylonian translation at Behistun was recoverable, his progress had been necessarily slow and for a long period anything but satisfactory. Recently however by the aid of an extensive and profound examination of the independent inscriptions of Assyria and Babylonia, more certain results had been obtained, and there could now be little question, but that a continued application of patient labour and critical skill, was alone required to render the Assyrian inscriptions at least as well understood as the Persian.

The third portion of the lecture referred to the results in regard to general knowledge at which we had already arrived through the interpretation of Cuneiform records. These results, although they contained nothing of any salient interest, were equally varied and extensive. We had obtained a general outline of the history of Western Asia from a period at least as early as the emigration of Abraham from Chaldæa, down to the age of Alexander the Great; and of many portions of that great historical interval we had the most minute and circumstantial notices, the Assyrian kings having

often chronicled the public transactions of their respective reigns with characteristic brevity, but with what appeared to be a conscientious and painstaking accuracy. Estimating the duration of the Assyrian monarchy at 1900 years, or from about 2500 to 600 B. C., there must have been a line of at least seventy kings, independent of interregnums. Of this line, however, there have only been recovered as yet the names of about twenty-five kings, and the longest succession that has been found consists of eight, or at most ten, consecutive generations. In Chaldæa and Babylonia, the historical information obtained has been even more fragmentary; for although we have now the names of nearly twenty kings, there is no continuous genealogy beyond that of father and son. A list of six, or perhaps eight, kings is given in the inscriptions of Armenia; and Susa and Elymais contribute several independent royal titles.

Besides the historical inscriptions of Assyria and Babylonia, there are many other miscellaneous Cuneiform documents. One class of inscriptions refers particularly to the construction of the palaces and temples, the architectural description resembling in its detail the Scriptural account of the building of Solomon's Temple. Others are especially devoted to the enumeration of the gods and the declaration of their titles and attributes, the figures of the deities invoked being sometimes engraved upon the monuments by way of illustration; evidence being thus afforded that the winged and monstrous forms depicted on the Assyrian marbles in the British Museum, are in no case intended to represent the Assyrian Gods, but have exclusively a symbolical signification. A pictorial representation was exhibited at this lecture of the Babylonian Pantheon copied from that interesting monument named Michaux's Stone, and an attempt was made to identify the figures, which evidently belonged to a Planetary or Celestial system of worship, with the gods mentioned in scripture, and commonly noticed in the inscriptions.

A further class of documents was noticed consisting of inscriptions on pieces of stone, of pottery and of "terra cotta." These inscriptions represented conveyances of property, deeds of sale, leases, contracts, mortgage bonds, and appeared sometimes to constitute documents resembling the exchequer bills and bank notes of modern times. It was conjectured indeed that prior to the introduction of coined money, the Assyrians and Babylonians must have made use of the clay cakes of which great numbers are now found in the country, as a circulating medium, thus, as it were, anticipating the modern invention of a paper currency.

A *resumé* was then given of the information afforded by the inscriptions as to the Political Geography and the Ethnography of Western Asia, at a period long anterior to what we have been hitherto accustomed to regard as authentic history, and the Lecturer stated in conclusion, that although he was about to return almost immediately to the East, he should leave sufficient data in the hands of the learned of Europe to enable them, as materials were

accumulated, to carry out with complete success the work of Assyrian decipherment and interpretation. H. C. R.

[For further information on this interesting subject, the Members are referred to the Journal of the Royal Asiatic Society, Vols. x. xi. xii..

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In the Library were exhibited :—

Kircher, Turris Babel — Kæmpfer, Amœnitates Exoticæ — Inscriptions in the Cuneiform Character, published by the British Museum — Layard's Nineveh and its Remains — C. J. Rich, Memoir on Babylon — Morier's Travels in Persia [from R. I. Library].
A Slab of Ivory from Nineveh, magnified 9 times — Lion Hunt, bas relief, from N. W. Palace, Nimroud, orginal size [by G. Scharf, Esq].
Babylonian Bricks, &c. [from R. I. Museum].
Models of Column from Birs Nimroud, Egyptian Obelisks, and Vases [by Mr. Tennant].
Specimens of Gold Quartz and Alluvial, from California [by Capt. Jackson].
Objects (named) from Hindostan and Persia [by Royal Asiatic Society].
Protean Stone (imitation of Marbles) — Imitation Ivory [by Mr. B. Chiverton].
Fac-Simile of Seal of Exchequer, temp. Edw. III. [by Mr. Barclay].
Vase from Athens — Roman Vase, &c. [United Service Institution].
Great Exhibition Commemoration Shield, designed by L. Limner, executed by Elkingtons [by Messrs. Leightons].
Group of Natural Objects coated with Silver [by Mr. Shuckard].

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## GENERAL MONTHLY MEETING,

Monday, June 2.

William Pole, Esq., M.A., F.R.S., Treasurer and Vice-President, in the Chair.

The Earl of Liverpool, G.C.B.
William Raikes Timmins, Esq.

were *admitted* Members of the Royal Institution.

Laurence Engstrom, Esq.
Mansfield Parkyns, Esq.
Wm. H. Fitton, M.D. F.R.S.
W. S. W. Vaux, Esq.

were duly *elected* Members of the Royal Institution.

The decease of Sir William Morison, K.C.B. M.P. &c. late Manager of the Royal Institution, was announced from the Chair.

The Managers reported,

That henceforth the Upper Library would be kept open from 10 o'clock A.M. till 10 o'clock P.M. on every day that the Institution is open; except on those Fridays on which the Weekly Evening Meetings are held, when it would be closed at 4 o'clock P.M., and at such times as it may be closed by special order.

They further reported that they had engaged Mr. C. W. Vincent, son of the Keeper of the Library, as Assistant in the Library, at a salary of £35 per annum.

The following PRESENTS were announced and the thanks of the Members ordered to be returned for the same; —

FROM

*John Prosser, Esq.* — Four Political Tracts (by Dr. Johnson). 8vo. 1770-5.

*The Institution of Civil Engineers* — Proceedings for May 1851. 8vo. 1851.

*W. F. Stevenson, F.R.S. (the Author)* — Memoir presented to the Royal Society demonstrating the fallacy of the supposed Composition of Water. 12mo. 1851.

*Gordon Willoughby James Gyll, Esq. M.R.I.* — The Enchiridion; or Sum of Human Science. 12mo. 1826.

*The Geological Society* — Quarterly Journal, No. 26. 1851.

*John Weale, Esq. (the Editor)* — London Exhibited in 1851. 12mo. 1851.
Rudimentary Book-Keeping; by James Haddon, M.A. 12mo. 1851.
Rudimentary Treatise on Logarithms, &c. by H. Law, Esq. 12mo. 1851.

*Royal Medical and Chirurgical Society* — Medico-Chirurgical Transactions, Vol. xxvii —xxxii. 8vo. 1844-9.

*George Rush, Esq. (the Author)* — An Account of Ascents in the Victoria and Nassau Balloons, in 1838, 1849, 1850; and an Appendix by W. H. Jones, consisting of Tables for Measurement of Heights, &c. 8vo. 1851.

*G. B. Airy, Esq. Astronomer Royal, &c.* — Suggestions to Astronomers for the Observation of the Total Eclipse of the Sun, on July 28, 1851. 8vo. 1851.

*Hercules Sharpe, Esq. M.R.I.* — Nouvelle Route pour la Californie et de la Colonisation de Costa Rica. 8vo. Paris. 1851.

*M. Faraday, Esq., Full. Prof. Chem. R.I.* — Bulletin de la Classe Physico-Mathématique de l' Academie Impériale des Sciences de St. Petersbourg. Tome IX. Nos. 7 — 16. 4to. 1850.

*Alexander Harpur, Esq. (the Author)* — An Inquiry into the Essential Nature of Phenomena or Perceptible Existence, &c. &c. 8vo. 1850-1.

*Allen Davis, Esq. M.R.I.* — Communications on Farming, by Hewitt Davis. 8vo. 1831-50.

*The Managers of the London Institution.* — A Bibliographical Account and Collation of " La Description de l'Egypte," &c. (*Not Published.*) 8vo. 1838.

*The Royal Institute of British Architects.* — Proceedings for May, 1851. 8vo. 1851.

*The Athenæum Club.* — Annual Report, &c. for 1851. fol.

*Edward B. Lovell, Esq., M.R.I. (the Author)* — Hand-Book of the New Chancery Orders, April 22, 1850. 12mo. 1850.
The Monthly Digest, 1850: an Analytical Digest of Equity, Common Law, Bankruptcy, Ecclesiastical and Criminal Cases, &c., with a Digest of the Statutes. 8vo. 1850.
Ditto. Nov. 1850 — April, 1851. 8vo. 1851.

*Der Vereins zur Beförderung des Gewerbfleisses in Preussen* — Verhandlungen, 1849-50. 4to. Berlin, 1849-50.
*Benj. Gibbons, Esq. M.R.I.* — Proceedings of the Institution of Mechanical Engineers, Birmingham, April 23, 1851. 8vo.
*Reginald J. Morley, Esq. M.R.I.*—An Analytical Digest of all the Reported Cases decided in the Supreme Courts in India, &c. with an Introduction and Notes; by W. H. Morley, Esq. 2 vol. 8vo. 1850.
*Henry Twining, Esq., M.R.I. (the Author.)* — Inquiry into the Nature and Application of Perspective and Foreshortening. 8vo. 1850.
*Jacob Bell, Esq., M.P., M.R.I. (the Editor.)* The Pharmaceutical Journal for June, 1851. 8vo.
*The Editor* — The Athenæum for May, 1851.
*Charles Babbage, Esq., (the Author)* — The Exposition of 1851; or Views of the Industry, the Science, and the Government of England. 8vo. 1851.
— *Mc Dowal, Esq.* — Specimens of Franklinite and Red Oxide of Zinc.

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## WEEKLY EVENING MEETING,

Friday, June 6.

The Duke of Northumberland, President,
in the Chair.

Professor Alexander Williamson,
UNIVERSITY COLLEGE, LONDON.

### *Suggestions for the Dynamics of Chemistry derived from the Theory of Etherification.*

The human mind is only capable of understanding complicated phenomena when prepared by the study of simpler ones; and one of the most remarkable illustrations of this necessary order is afforded by the preparation of dynamical laws by the consideration of statical facts. In statics we consider phenomena in a state of rest, while in dynamics we study their change; and this distinction has been concisely stated by saying that the transition from the statical to the dynamical point of view, consists in superadding the consideration of *time* to that of space.

To represent the unknown cause of any change in phenomena, the word force has been formed, and is generally retained until the law of that change has been discovered; so that the dynamics of a subject may be said to constitute the explanation of the phenomena belonging to it.

It unfortunately often occurs that names are mistaken for explanations, and people deceive themselves with the belief that, for instance, in attributing chemical decompositions to affinity, attraction, contact-force, catalysis, &c., they explain them.

But owing to the necessary dependence of investigations on our

mental operations, there is always a deficiency of facts corresponding to the imperfection of theory;—that is, we only seek and see those facts which are more or less connected with our theoretical notions, and in most cases shut our eyes to such cases as appear contrary to them. This is peculiarly the case with chemical theory and chemical facts at the present day; for our atomic theory represents only certain simple and definite proportions of combination, and our researches have been fruitful in the investigation of such cases alone, the number of compounds of which we know nothing being infinite, compared to those definite ones which we have studied.

In fact, it is certain that if we could sufficiently disengage our minds from preconceived notions on the subject, we should view those substances, which, by more or less troublesome processes, we separate out from the bodies presented to us by nature, rather as exceptional and artificial products, than as the most normal and natural.

The lecturer submitted that the definite compounds hitherto exclusively acknowledged and studied by chemists, are in truth only exceptionally simple cases of combination, and that the consideration of chemists is only limited to them, because the atomic theory is as yet purely statical. The atomic theory has hitherto been tacitly connected with an unsafe and unjustifiable hypothesis, namely, that the atoms are in a state of rest; the dynamics of chemistry will commence by the rejection of this supposition, and will study the degree and kind of motion which atoms possess, and reduce to this one fact the various phenomena of change, which are now attributed to occult forces. But although it will probably be generally used in connection with the atomic theory, the fact of motion is independent of any particular theory; and however the properties of matter may be conceived, it will remain true, that a change of place among the representatives or possessors of these properties, is constantly going on, which produces the phenomena of chemical combination.

Chemical science has proved the indestructibility of matter, but it has yet to prove the indestructibility of motion or momentum by showing its transfer and dispersion among atoms.

There are many *primâ facie* evidences that *time* is necessary for chemical action: — but this fact, although it has been noticed, has not as yet entered into the explanation of phenomena.

The one instance in which a certain regular motion of the constituents of a mixture was first proved, is the process of etherification, of which the anomalous character has long since attracted the attention and study of many of the most eminent chemists, and has given rise to various theories which respectively represented part of the phenomena.

The lecturer referred to the importance of having a correct standard of comparison for the various chemical groups or molecules, and briefly alluded to the evidence afforded by the formation of the intermediate ethers, that alcohol and various bodies allied to it have

of late years been incorrectly represented comparatively to metallic oxides and ethers, and that the weight of alcohol which is truly equivalent to ether or water, is not 46 but 23.

Having proved by a direct experiment that the formation of ether from alcohol is effected by substituting ethyle ( $C_4 H_5$ ) for $\frac{1}{6}$ of the hydrogen of that body, the process of etherification by sulphuric acid was explained by a diagram, on which half the hydrogen in sulphuric acid was shown to change places with its analogue ethyle in alcohol; and that the peculiarity of the process, *i. e.* its continuity, is owing to this change of place between hydrogen and ethyle, first taking place in one direction and then in the opposite; that is, that sulphuric acid becomes sulphovinic acid by taking up ethyle instead of an atom of hydrogen, and that it is then re-converted into sulphuric acid by resuming hydrogen instead of this ethyle, the first change forming water, the second ether.

By using successively two different alcohols, it was shown that the two steps of this decomposition can be separated and their reality proved. The process of etherification is thus effected by a succession of double decompositions, each of which considered individually is perfectly conformable to the law of definite proportions; but the alternation and continuous succession so clearly proved in them, is a fact unexplained by that law. A complete analogy between this process and the more familiar cases of chemical action is therefore only to be established by finding in these latter a similar atomic motion.

A little reflection is sufficient to show that such a motion actually exists. The fact of diffusion is in reality nothing but a change of place between atoms, effected by the mere action of the particles on one another; and there are many mechanical evidences of the communication of momentum from masses to atoms, and inversely.

It seems perhaps difficult to reconcile the apparent rest of the constituents of a mass with the existence of a continuous atomic motion; but there are many cases in which a rapid and continuous motion produces to our senses the appearance of a phenomenon at rest: thus, the rapid revolution of a white sphere produces the appearance of a circle at rest when seen in front, and that of an ellipse when viewed obliquely.

There are of course many points of view from which the motion of atoms may be considered; but it is inasmuch as it produces or facilitates decomposition, that the chemist has to regard it. We have in etherification an evidence of the tendency of atoms of analogous nature to change places continuously; and it is natural to suppose that the facility of this interchange must be greater in proportion to the analogy between the molecules, and greatest between like molecules. The lecturer expressed a confident hope that he would soon be able to give a direct experimental evidence of this conclusion, and proceeded to show how the admission of it explains, without the supposition of occult forces, the occurrence of double decompositions and the action of masses.

The exchange of analogous particles actually constitutes double decomposition; and its occurrence in alternately opposite directions causes the two substances used to alternate with the two other compounds formed by the exchange of their bases; so that in such a mixture, four substances are constantly to be found, the quantity of each substance corresponding to the average number of atoms which, in each moment of time, are in that state of combination.

Now it is clear that if an equal number of atoms of a hydrogen-salt, and of an iron-salt, reacting on one another, form a certain amount of the products of their double decomposition, a greater number of those products will be formed by doubling the quantity of the hydrogen-salt; for, the facility of interchange of iron with hydrogen remaining the same, the atoms of the iron-salt will then come more frequently in contact with those of the hydrogen-compound. Thus, on mixing a solution of sesquichloride of iron with sulphocyanide of hydrogen, a deep red colour gave evidence of the interchange of iron and hydrogen, forming sulphocyanide of iron and hydrochloric acid: but this exchange was not an operation effected once for all on the decomposing substances just coming in contact, but is constantly going on in the mixture; and the quantity of the products of this interchange remains constant, because a similar double decomposition, equal in absolute number of atoms per unit of time, is constantly going on between these products, reproducing the original compounds. In evidence of this, the counterpart of the decomposition of sesquichloride of iron by hydrosulphocyanic acid was shown in the expulsion of this last acid by hydrochloric, proved by the gradual diminution of the red colour on adding hydrochloric acid.

It is well known that caustic soda expels ammonia from its salts. But ammonia also expels soda: for it was shown, that a mixture of ammonia and hydrochlorate of soda dissolves less chloride of silver than the same quantity of ammonia alone; and consequently, that a saturated solution of chloride of silver in aqueous ammonia is precipitated by dissolving chloride of sodium in it. The same occurs with the ammonio-sulphate of copper.

In conclusion, the lecturer referred to the question of the relative velocity of transfer of analogous atoms in opposite directions, which necessarily determines the proportion of the elements of two salts, contained in the form of their products of double decomposition, on these salts being mixed. On the mixture of equivalent proportions of a couple of salts in aqueous solution, a certain amount of decomposition ensues, forming two other salts, and the chemical force may be considered proportional to the quantity of one couple compared to that of the other. Now as the proportion is only kept up by the number of exchanges in the one direction being ABSOLUTELY the same in each moment of time as those in the opposite direction, it is clear that the relative velocity of interchange must be greatest between the elements of that couple of which the quantity is least; and

**chemical force must be inversely proportional to the velocity of these interchanges.** A. W. W.

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In the Library were exhibited: —

Specimens of the right and left Tartaric Acid and their Salts, exhibiting hemi-hedrism in their Crystalline Forms — with Models and Figures illustrating their characters; sent by M. Pasteur to illustrate the lecture given by Mr. Maskelyne on Friday, March 28. [by Nevil Story Maskelyne, Esq., vide p. 45.]
Specimens of Kreatine and Kreatinine [by Mr. Bullock].
Woorari or Ourari Poison, and arrows armed with it, used by the natives of Guayana to kill game, supposed to be prepared from Strychnos — Upas Antiar Poison from Java — Specimens of Gluten Bread, and Bread from Janipha Manchot, British Guiana [by the Pharmaceutical Society].
Pheasants [mounted by Messrs. Leadbeaters].
Four Photographic Views of Edinburgh from Negatives on Glass, by Messrs. Ross and Thompson, Edinburgh [by Messrs. Henneman and Malone].
A Series of 23 drawings made from Sketches taken on the spot, illustrating the Life and Writings of Wordsworth [by Mr. T. Shuckard].
The late Bishop of Chichester (in Machine Sculpture) [by Mr. Chiverton.]
Fac-Similes of Ancient Coins [by Mr. Barclay.]

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## WEEKLY EVENING MEETING,

Friday, June 13.

The Duke of Northumberland, President, in the Chair.

Professor Faraday,

*On Schönbein's Ozone.*

The object of the speaker was to give a brief account of the present state of this subject; taking at the same time notice of the ancient facts which belong to it, and the high hopes of progress which it offers for the future. Ozone is produced when the electrical brush passes from a moist wooden point into the atmosphere, and indee

in almost every case of electrical discharge in the air; or when water is electrolyzed, as in the case of a dilute solution of sulphuric acid or sulphate of zinc; or when phosphorus acts at common temperatures on a moist portion of the atmosphere. For the latter case take a piece of clean phosphorus about half an inch long which has been recently scraped; put it into a clean two-quart bottle, at a temperature of about 60° F. with as much water as will half cover the phosphorus; close the mouth slightly so that if inflammation take place no harm may happen; and leave it. The formation of Ozone will quickly occur, being indicated by the luminous condition of the phosphorus, and the ascent of a fountain-like column of smoke from it. In less than a minute the test will show Ozone in the air of the bottle, in five or six hours it will be comparatively abundant; and then the phosphorus being removed and the acids formed at the time washed out, the bottle may be closed and made use of when required for experiments.

The test for Ozone is as follows: 1 part of pure iodide of potassium, 10 parts of starch, and 200 parts of water are to be boiled together for a few moments. A little of this preparation placed on writing paper with a brush being introduced into the Ozone atmosphere is rendered instantly blue from the evolution of iodine:— or if bibulous paper be dipped into this solution, and then dried, it forms Schönbein's Ozonometric test: for a slip being introduced dry into an atmosphere supposed to contain Ozone, after remaining there a longer or shorter time, on being removed and then moistened, instantly becomes more or less deeply blue if Ozone be present.

Ozone when obtained by the three very different processes described is identical in every respect: its properties are as follow: 1. It is a gaseous body of a very peculiar odour: when concentrated the odour approaches to that of chlorine; when diluted it cannot be distinguished from what is called the electric smell. 2. Atmospheric air strongly charged with it renders respiration difficult, causes unpleasant sensations, and produces catarrhal effects (by acting powerfully on the mucous membranes). Such air soon kills small animals, as mice, placed in it; so that Ozone in its pure state must be highly deleterious to the animal economy. 3. It is insoluble in water. 4. Like chlorine, bromine, and the metallic peroxides, it is a powerful electromotive substance. 5. It discharges vegetable colours with a chlorine-like energy. 6. It converts phosphorus ultimately into phosphoric acid; it combines with chlorine, bromine, and iodine; it does not unite with nitrogen under ordinary circumstances, but does when lime water is present; and nitrate of lime is formed from which nitre may be readily obtained. 7. At common and even low temperatures it acts powerfully upon most metallic bodies, producing the highest degree of oxidation they are capable of. Lead and even silver is carried at once to the state of peroxides; arsenic and antimony produce arsenic and stibic acids. 8. It transforms many of the lower oxides into peroxides; thus, the hydrate of the oxides of

lead, cobalt, nickel, and manganese become in it peroxides: the ba oxide of silver undergoes the same change. 9. It decompos rapidly the solid and dissolved protosalts of manganese; the h drated peroxides of the metal being formed, and the acid of the sa evolved. 10. It decomposes the solution of the tribasic acetate lead; the peroxide of that metal and the ordinary acetate bei formed. 11. It rapidly converts the protosalts of iron and tin in persalts. 12. It destroys many hydrogenated gaseous compound the combinations of hydrogen with sulphur, selenium, phosphor iodine, arsenic, and antimony are thus affected. It appears to un chemically with olefiant gas in the manner of chlorine. 13. It stantly transforms the sulphurous and nitrous acids into the sulphu and nitric acids, and the sulphites and nitrites into sulphates a nitrates. 14. It changes many metallic sulphurets (as those of le and copper) into sulphates. 15. It decomposes many iodides their solid and dissolved state. By its continued action iodide potassium becomes converted into iodate of potassa. 16. It chan both the crystallized and dissolved yellow prussiate of potassa in the red salt, potash being evolved. 17. It produces oxidizi effects upon most organic compounds, causing a variety of chemi changes; thus guaiacum is turned blue by it. From the ab enumeration it would appear that Ozone is a most ready and pow ful oxidizer, and in a great number of cases acts like Thenar peroxide of hydrogen, or chlorine or bromine.

A number of the actions of this body, such as the bleaching indigo and litmus, the peroxidation of metals, the conversion sulphurets into sulphates, &c. were shown, to illustrate the chlori like action of the Ozone; and many illustrations supplied M. Schönbein himself were exhibited.

With respect to the nature of this body, the two cl ideas are — that it is a compound of oxygen analogous the peroxide of hydrogen, or that it is oxygen in an allotro state, *i. e.* with the capability of immediate and ready act impressed upon it. When an ozonized atmosphere is made as as possible, and then sent through a red hot tube, the Ozone dis pears, being converted apparently into ordinary oxygen, and water or any other result is produced. This agrees with the kno fact, that heat prevents the formation of Ozone, and also w the idea that Ozone is only oxygen in an allotropic state. To sh that heat prevents the formation of Ozone a little voltaic batt was associated with a fine platina wire helix, insulated, and connec with the electrical machine; at first the circuit between the batt and the helix was left incomplete; and then on working machine the brush thrown off from the helix affected the t paper, before described, by the Ozone in it; but when the co nexion was complete, so that the helix was ignited, then electrical brush from it had no power of producing any effect Ozone.

The speaker described the presence of Ozone in the atmosphere, the mode of testing its presence, and the probable effects it produced there. He referred to Schönbein's recent experiments on the insulation of the oxygen of the air and the peculiar effects produced by this action. He showed by experiments the more recent results of the association of oxygen by light with oil of turpentine and other bodies; and the production of bleaching compounds vying with the hypochlorite of lime in energy. He made it manifest by experiment, that when ether vapour is mixed with air, and a hot platina wire or glass rod introduced, the ether in becoming partially oxidized to produce acid, also produces Ozone, the results bleaching indigo powerfully; and he stated that sulphurous acid, ether, tartaric acid, and many other substances which being first mixed with air or oxygen were then exposed to sunlight, exerted bleaching powers often of a very high degree. The evening concluded with the expression of certain theoretical expectations, or rather possibilities, which were put forth as indicating the probable fertility and importance of the subject, and fitted to excite such philosophers as were engaged in the consideration of the physical qualities of the particles of matter to examine how far the phenomena of Ozone might be carried onward in the illustration and extension of their researches.

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In the Library were exhibited: —

Studies of Light and Shade (Views in Switzerland,) exemplifying one of the rapid modes employed by Artists to convey the impressions they have received to paper or canvas; and which remains as a reminiscence of their first ideas while they are engaged in combining form, light, shade, and colour into one harmonious whole [by G. Barnard, Esq.]

A (so called) Blind Fish, and a kind of Lobster from a Mammoth Cave in Kentucky, United States.— Dr. Wyman, in the American Journal Natural Sciences for 1843, has described a (blind ?) fish which he thinks analogous to but not identical with the Amblyopsis Spelæus described by Dr. Dekay in the Fauna of New York. Professor Owen (Lectures on Comparative Anatomy, Vol. II. page 175.) has given a plate of the brain of the Amblyopsis Spelæus [by G. Macilwain, Esq. M.R.I., &c.]

Photographs (by Dr. A. Taylor) from Negatives taken on the spot (those in Paris by Mr. Mayall, those in Upper Egypt by Mr. Spencer Wells) [by Dr. A. Taylor, M.R.I. &c.]

Specimens of Malachite (Carbonate of Copper) from an open cavern at the surface of the ground, near Ambrix on the Western (Congo) Coast of Africa, exhibiting the manner of the formation of the Mineral as a Stalactite [by C. B. Mansfield, Esq. M.R.I.]

Magnetic Stone found at Sangor, Central India [from the Museum of Economic Geology].

Specimens of Meconic Acid — Sulphate of Strychnia — Codea-Furfuramide (Fownes) [by T. N. R. Morson, Esq. M.R.I.]

Eagle Owl (Stryx Bubo) — Snowy Owl (Strix Nyctea) — Snow Owl (Ibis Rubra) [mounted by Messrs. Leadbeaters.]

Specimens of Tea, adulterated by the Chinese by facing it with mixture of Prussian Blue, Turmeric, and Gypsum, containing 45 per cent. of sand and dirt, [by Robert Warrington, Esq.]

Zinc, Steel and Iron, brassed and bronzed by Salzede's process [b Messrs. Green and Prince].

Allotropic Phosphorus [by Dr. Percy].

An Apparently Fossil Human Leg, (from Bermuda) — Specimens Lace-bark Tree,) from Jamaica) — Mexican Boots — Wax Tape (from Bahia) — Carved Box, (from New Zealand) — [by th United Service Institution.]

Nobili's Specimen of Metallo-Chrome, presented by himself to th Royal Institution.

Specimens of Coral [by Mr. Tennant].

[FOR THE USE OF MEMBERS.]

# Royal Institution of Great Britain.

## 1851.

GENERAL MONTHLY MEETING,

Monday, July 7.

GEORGE DODD, Esq., M.P., F.S.A., in the Chair.

Frank Bradshaw, Esq. | Thomas Rogers, Esq.
John Deacon, jun. Esq. | Alexander Stewart, Esq.

were duly *elected* Members of the Royal Institution.

William Henry Blaauw, Esq., F. S. A. was unanimously elected a MANAGER of the Royal Institution in the room of General Sir William Morison, K.C.B. deceased.

The following PRESENTS were announced, and the thanks of the Members returned for the same:—

FROM

*Anonymous*—A Plea on behalf of Publicans against Drunkards, by B. D. 12mo. 1851.
The Whole Doctrine of the Sabbath, as set forth in the Holy Scriptures, &c. by J. W. 12mo. 1851.
*Asiatic Society of Bengal*—Journal, No. 217, 218. 8vo. 1850-1.
*Bell, Jacob, Esq. (the Editor)*—The Pharmaceutical Journal, July, 1851. 8vo. 1851.
*Bleekrode, Prof. S.* (*the Author*)—Jaarboekje van Wetenschappen en Kunsten; vierde Jaargang. 12mo. Gorinchem, 1850.
*British and Foreign Bible Society*—The HOLY BIBLE, in 25 Languages.
The OLD TESTAMENT in German and Hebrew.
The NEW TESTAMENT, in 42 Languages.
Other Parts of the Bible, in 15 Languages.
Reports, Vol. V.—XV. 1818.—1848. 8vo.
*British Association for the Advancement of Science*—Report of the Twentieth Meeting held at Edinburgh, 1850. 8vo. 1851.
*Carpenter, William B., M.D., F.R.S.* (*the Author*)—Principles of Physiology, General and Comparative. Third edition. 8vo. 1851.
*Council of Education of Bengal*—General Report of Public Instruction in the Lower Provinces of the Bengal Presidency, 1849, 1850. 8vo. Calcutta, 1851.
*Editor*—The Architectural Quarterly Review, Vol. I. No. 1. 8vo. 1851.
The Athenæum for June, 1851.
*Faraday, M. Esq.*—Kaiserlichen Akademie der Wissenschaften, Wien.
*Denkschriften:*—
Philosophisch-Historische Classe, Band I. und II. Abtheilung I. Wien, 1850.
Mathematisch-Naturwissenschaftliche Classe, Band I. Wien, 1850. 2te. Band, 1ste und 2te Lieferung. 4to. Wien, 1850.

*Sitzungsberichte:*—
Math.-Nat. Classe, Oct.—Dec. 1850. Phil.-Hist. Classe, Oct.—Dec. 1850. 8vo. Wien, 1851.
Fontes Rerum Austriacarum, Band III. Abtheilung 2. 8vo. Wien, 1851.
Die Antiken Cameen des K. K. Münz und Antiken Cabinettes in Wien: beschrieben von Joseph Arneth. Fol. Wien, 1849.
Die Antiken Gold und Silber Monumente des K. K. Münz und Antiken Cabinettes in Wien: beschrieben von Joseph Arneth. Fol. Wien, 1850.
Monatsberichte der Königl. Preuss. Akademie der Wissenschaften zu Berlin, März und April, 1851. 8vo.
Jahresbericht des Physikalischen Vereins zu Frankfort-am-Main, 1849-50. 8vo.
Atte dell' Academia Pontificia de' Nuovi Lincei, Anno IV. Sessione 1-3. 4to. Roma, 1851.

*Franklin Institute*—Journal, 3rd Series. Vol. XX. 8vo. Philadelphia, 1850.

*Jones, T. Wharton, F. R. S. (the Author)*—The Wisdom and Beneficence of the Almighty as displayed in the sense of Vision. (The Actonian Prize Essay for 1851.) 16mo. 1851.

*Linnean Society of London*—Transactions. Vol. XX. Part 3. 4to. 1851.
Proceedings, No. 44. 8vo. 1851.

*Lovell, E. B. Esq. M. R. I. (the Editor)*—The Monthly Digest, June, 1851. 8vo.

*Nicol, W., Esq. M. R. I.*—Fac-simile in all but colour of the Remains of a Portrait on Panel of William Shakspeare, by Richard Burbage his fellow Player and Partner, 1597.— 1851.

*Royal Astronomical Society*—Proceedings, Vol. XI. No. 5, 6, 7. 8vo. 1851.

*Royal Institute of British Architects*—Lists of Members, Report of Council, &c. 4to. 1851.
Proceedings for June, 1851. 4to.

*Royal Society of Londan*—Proceedings, Vol. VI. No. 78, sheet 3. 8vo. 1851.
Philosophical Transactions for 1851. Part I. 4to. 1851.

*Savage, Miss A.*—A Dictionary of the Art of Printing by W. Savage. 8vo. 1841.

*Statistical Society*—Journal, Vol. XIV. Part 2. 8vo. 1851.

*Taylor, A. S., M. D., F. R. S., M. R. I.*—Report on the Water of the West Middlesex Water-works Company, by A. S. Taylor, M. D. and A. Aikin, F. L. S. 8vo. 1851.

*Vereins zur Beförderung des Gewerbfleisses in Preussen*—Verhandlungen, January zu April, 1851. 4to.

*Weale, John, Esq.*—Rudimentary Treatise on Ship-building, by James Peake, N.A. Parts II & III. 12mo. 1851.
Examples and Solutions in the Differential Calculus, by James Haddon, M. A. 12mo. 1851.

*Webster, John, M.D., F.R.S., M.R.I., &c.* St. Luke's Hospital for Lunatics—Physicians' Report for 1850. 8vo. 1851.
On the Health of London during the Six Months terminating March 29, 1851. 8vo. 1851.

## GENERAL MONTHLY MEETING,

Monday, November 3.

SIR CHARLES FELLOWS, in the Chair.

Thomas Rogers, Esq. was *admitted* a Member of the Royal Institution.

Warren De la Rue, Esq. F.R.S.
Samuel Gaskell, Esq.
Robert Hanbury, jun. Esq.
Walter Spencer Stanhope, Esq.

were duly *elected* Members of the Royal Institution.

The Managers reported, that they had appointed THOMAS WHARTON JONES, Esq., F.R.S. to fill the vacant office of Fullerian Professor of Physiology.

The following PRESENTS were announced, and the thanks of the Members returned for the same:—

FROM

*Académie Impériale des Sciences de St. Petersbourg*—Mémoires, 6e Série. 4to. 1850-1. Sciences Mathématiques, &c. Tome IV. Livraisons 3 & 4.
Mémoires par des Savans Etrangers. Tome VI. Livraisons 5 & 6. 4to. 1851.
*Admiralty, Board of*—Contributions to Astronomy and Geodesy: by T. Maclear, Esq. 4to. 1851.
*Airy, G. B., Esq., F.R.S., Astronomer Royal*—Reports of the Astronomer Royal on Greenwich Observatory, 1836 to 1851. 4to.
*American Philosophical Society*—Proceedings, No. 46. 8vo. 1851.
*Asiatic Society of Bengal*—Journal, No. 203, 219, 221. 8vo. 1849-1851.
*Ayrton, W. S., Esq. (the Author)*—Suggestions referred to those interested in the Reform of the Law. 8vo. 1851.
*Barlow, Rev. John, M.A., F.R.S., Sec. R.I.*—Report of the History, and Recent Collation of the English Versions of the Bible; adopted by the American Bible Society. 8vo. 1851.
*Bell, Jacob, Esq., M.P., M.R.I., (the Editor)*—The Pharmaceutical Journal for August to November. 8vo. 1851.
*Bigsby, John J., M.D., M.R.I., &c. (the Author)*—The Shoe and Canoe; or Pictures of Travel in the Canadas, &c., with Plates and Maps. 2 vol. 16mo. 1850.
*Chemical Society*—Journal, No. 14, 15. 8vo. 1851.
*Council of Education, Calcutta*—Annual Report of the Medical College of Bengal, 1850-1. 8vo. 1851.
*D.C.L. (the Author)*—Letters on Church Matters, Vol. II. 8vo. 1851.
*Duprez, M. F. (the Author)*—Mémoire sur un Cas particulier de l'Equilibre des Liquides. 1re Partie. 4to.
*Editor*—The Athenæum for July to October 1851. 4to.

*Faraday, M., Esq., F.R.S., &c.*— Monatsberichte der Königl. Preuss. Akademie der Wissenschaften zu Berlin; Mai, Juni, Juli und August, 1851. 8vo. 1851.

Verhandlungen der Königl. Akademie der Wissenschaften zu Berlin, 1849. 4to. Berlin, 1851.

Lieutenant Maury's Investigations of the Winds and Currents of the Sea. with Charts. 4to. Washington, 1851.

Researches in Magnetism, Electricity, &c. by Karl Baron von Reichenbach; translated and edited by W. Gregory, M.D. Parts 1 and 2. 8vo. 1850.

Die totale Sonnenfinsterniss am 28 Juli, 1851 — Vortrag von Professor S. Stampfer. 8vo. Wien, 1851.

Tijdschrift voor de Wisen Natuurkundige Wetenschappen uitgegeven door de Eerste Klasse van het Koninklijk Nederlandsche Instituut van Wetenschappen, &c. Derde Reeks, Vierde Deel. Amsterdam, 4to. 1851.

*Franklin Institute* — Journal, Vol. XXII. No 1. 8vo. 1851.

*Geological Society* — Quarterly Journal, No. 27. 8vo. 1851.

*Glover, J. H. Esq.* (Librarian to Her Majesty) — Bibliothecæ Regiæ Catalogus, 5 vol. Fol. 1820-1829.

*Grant, James Gregor, Esq. (the Author)*— Madonna Pia, and other Poems. 2 vol. 16mo. 1848.

*Hennen, J., M.D. M.R.I.* — St. Gervais-les-Bains et le Mont Blanc — Aperçus topographiques, pittoresques et scientifiques. 18mo. Paris. [1851.]

*Her Majesty's Government (by Col. E. Sabine)* — Observations made at the Magnetical and Meteorological Observatory at the Cape of Good Hope, Vol. I. Magnetical Observations, 1841-6, 4to. 1851.

*Horticultural Society of London* — Journal, Vol. VI. Nos. 3, 4. 8vo. 1851.

List of Members, 1851.

*Liverpool Literary and Philosophical Society* — List of Communications, 1812-21. 12mo. 1821.

Proceedings. No. 1—6. 8vo. 1845-51.

Laws, 8vo. 1848.

*Lovell, E. B. Esq. M.R.I. (the Editor)* — The Monthly Digest of Equity, Common Law, &c. for July, August, September, and October. 8vo. 1851.

*Northumberland, Duke of* — Report of the Committee appointed to examine the Life-Boat Models submitted to compete for the premium offered by his Grace the Duke of Northumberland; with Maps and Plans. Folio. 1851.

*Radcliffe Trustees, Oxford* — Astronomical Observatory, Oxford, in 1849. Vol. X. 8vo. 1851.

*Raumer, Friedrich von, Hon. Mem. R. I. &c. (the Author)* — Geschichte Frankreichs und der Französischen Revolution, 1740—1795. 8vo. Leipzig, 1850.

*Real Academia de Ciencias de Madrid* — Memorias, Tomo I. Tercere Serie, Ciencias Naturales: Tomo I. Parte I. 4to. Madrid, 1850.

Resumen de las Actas en el año academico de 1849 á 1850, por el secretario perpetuo Dr. Dom M. Lorente. 4to. Madrid. 1850.

*Rennie, James, Esq. F R.S. M.R.I.* — Mathematical Tracts, by G. B. Airy. 3rd edition. 8vo. 1842.

*Royal Agricultural Society of England*—Journal, Vol. XII. Part I. 8vo. 1851.

*Royal Astronomical Society* — Monthly Notices, Vol. XI. No. 8. 8vo. 1851.

Memoirs, Vol. XIX. 4to. 1851. — Proceedings, Vol. X. 8vo. 1850.

*Royal College of Surgeons of England*—List of Fellows and Members, 8vo. 1851.

*Royal Cornwall Polytechnic Society*—Eighteenth Annual Report. 8vo. 1850.

*Royal Society of Van Diemen's Land*—Papers and Proceedings, Vol. I. Part 3. 8vo. Tasmania, 1851.

*Royal Society of Edinburgh*—Transactions, Vol. XX. Part 2. 4to. 1851.

Proceedings, Nos. 40, 41, and Title, Contents, &c. to Vol. II. 8vo. 1851.

*Smyth, Capt. W. H., R. N., (the Author)*—Address at the Anniversary Meeting of the Royal Geographical Society, May 26, 1851. 8vo. 1851.

*Squire, Peter, Esq., M.R.I.* (*the Author*)—The New London Pharmacopœia, translated and arranged in a Tabular Form with the Edinburgh and Dublin Pharmacopœias. 8vo. 1851.

*Statistical Society*—Journal, Vol. XIV. Part 3. 8vo. 1851.

*Vereins zur Beförderung des Gewerbfleisses in Preussen* — Verhandlungen, Mai und Juni, 1851. 4to. Berlin.

*Weale, John, Esq.*—Rudimentary Treatise on Mensuration, by T. Baker, C. E. 12mo. 1850.

Manual of the Mollusca, or Rudimentary Treatise on Shells Recent and Fossil; by S. P. Woodward. 12mo. 1851.

*Webster, John, M.D., F.R.S., M.R.I.*—Homœopathy. Report of the Speeches on Irregular Practice delivered at the 19th Meeting of the Provincial Medical and Surgical Association. 8vo. 1851.

*Wrontchenko, M. le Comte, &c.*—Annales de l'Observatoire Physique Central de Russie, par A. T. Kupffer, Année 1847. 4to. St. Petersbourg, 1850.

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## GENERAL MONTHLY MEETING,

Monday, December 1.

PROFESSOR CHARLES WHEATSTONE, F.R.S., Vice President, in the Chair.

Warren De la Rue, Esq. F.R.S. was *admitted* a Member of the Royal Institution.

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| Bernard Edw. Brodhurst, Esq. | John George Dodson, Esq. |
| John William Digby, Esq. | Edward Dolman Scott, Esq. |

were duly *elected* Members of the Royal Institution.

Col. Julius G. Griffith was unanimously elected a VISITOR of the Royal Institution in room of C. B. Mansfield, Esq., resigned.

The Secretary reported, that the following Arrangements had been made for the Lectures before Easter, 1852:

Six Lectures on Attractive Forces, (adapted to a Juvenile Auditory,) —by Professor FARADAY.

Twelve Lectures on Animal Physiology—by T. WHARTON JONES, Esq., F. R. S., Fullerian Professor of Physiology, R. I.

Eleven Lectures on the Physical Principles of the Steam Engine—by the Rev. JOHN BARLOW, M. A., F. R. S., Sec. R. I.

Eleven Lectures on some of the Arts connected with Organic Chemistry—by Professor BRANDE.

(Laboratory Lectures.) Twenty-five Lectures on the Chemistry of the Metals—by CHARLES BLACHFORD MANSFIELD, Esq.

The following PRESENTS were announced, and the thanks of the Members returned for the same ; —

FROM

*Asiatic Society of Bengal*—Journal, Nos. 108-110. 8vo. 1850.

*Astronomical Society (Royal)*—Monthly Notices, No. 9. 8vo. 1851.

*Bache, Dr. A. D., Superintendant of the United States Coasts Survey*—Charts of the Survey, 31 sheets.

*Babbage, Charles, Esq. (the Author)*—The Exposition of 1851, &c. Second Edition. 8vo. 1851.

*Bell, Jacob, Esq. M.P. M.R.I. (the Editor)*—Pharmaceutical Journal for December, 1851, 8vo.

*Editor*—Athenæum for November 1851. 4to.

*Faraday, Prof.*—Papers relating to the University of Sydney, New South Wales. 8vo. 1851.

Bulletin de la Classe Physico-Mathématique de l'Académie Impériale de St. Pétersbourg. Tome IX. No. 209-216. 4to. 1851.

Rapporte Generale della Pubblica Esposizione dei Prodotti Naturale e Industriale della Toscana, fatta in Firenze nel Novembre, 1850. 2 vol. 8vo. Firenze, 1851.

Memoria della Struttura Geologica delle Alpi degli Apennini e dei Carpazi, di Sir R. I. Murchison : traduzione dall' Inglese ed Appendice sulla Toscana dei Professori Cav. P. Savi e G. Meneghini. 8vo. Firenze, 1851.

*Geological Society*—Quarterly Journal, No. 28. 8vo. 1851.

*Institution of Civil Engineers*—Proceedings for Nov. 1851.

*Lovell, E. B. Esq., M. R. I., (the Editor)*—The Monthly Digest, Nov. 1851. 8vo.

*Morgan, J. M. Esq., M. R. I., (the Editor)*—The Triumph, or the Coming Age of Christianity, &c. 12mo. 1851.

Richard Baxter and other Divines on Christian Society. 18mo. 1851.

*Morell, Rev. Deacon, M. A. Life Subscriber R. I.*—The Scripture Doctrine of the Trinity, &c. by S. Clarke, D. D. 8vo. 1851.

*Royal Irish Academy*—Proceedings for 1850-1. 8vo.

*Royal Society of London*—Proceedings, Nos. 4, 5, 6, of Vol. VI. 8vo. 1851.

*Smithsonian Institution, Washington, U.S.*—Smithsonian Contribution to Knowledge, Vol. II. and Appendix to Vol. III. 4to. 1851.

Fourth Annual Report. 8vo. 1850.

Portrait of J. Smithson and View of Smithsonian Institution.

Reports on Planet Neptune and Public Libraries. 8vo. 1851.

Proceedings of the American Association for the Advancement of Science, 4th Meeting. 8vo. 1850.

*Vereins zur Beförderung des Gewerbfleisses in Preussen*—Verhandlungen, Juli und August, 1851. 4to.

*Wood, W., M.D., (the Author)*—Remarks on the Plea of Insanity and on the Management of Criminal Lunatics. 8vo. 1851.

*Yates, James, Esq. F.R.S., M.R.I. (the Author)*—Additional Observations on the Bulla worn by Roman Boys, &c. 8vo. 1851.

## 1852.

### WEEKLY EVENING MEETING,

Friday, January 23.

Sir John P. Boileau, Bart., F.R.S. V.P. in the Chair.

Professor Faraday,

*On the Lines of Magnetic Force.*

That beautiful system of power which is made manifest in the magnet, and which appears to be chiefly developed in the two extremities, thence called ordinarily the magnetic poles, is usually rendered evident to us in the case of a particular magnet by the attractive or repulsive effect of these parts on the corresponding parts of another magnet; and these actions have been employed, both to indicate the direction in which the magnetic force is exerted and also the amount of the force at different distances. Thus, if the attraction be referred to, it may be observed either upon another magnet or upon a piece of soft iron; and the law which results, for effects beyond a certain distance, is, that the force is inversely as the square of the distance. When the distances of the acting bodies from each other is small, then this law does not hold, either for the surface of the magnets or for any given point within them.

Mr. Faraday proposes to employ a new method, founded upon a property of the magnetic forces different from that producing attraction or repulsion, for the purpose of ascertaining the direction, intensity, and amount of these forces, not to the displacement of the former method but to be used in conjunction with it; and he thinks it may be highly influential in the further development of the nature of this power, inasmuch as the principle of action, though different, is not less magnetic than attraction and repulsion, not less strict, and the results not less definite.

The term *line of magnetic force* is intended to express simply the direction of the force in any given place, and not any physical idea or notion of the manner in which the force may be there exerted; as by actions at a distance, or pulsations, or waves, or a current, or what not. A line of magnetic force may be defined to be that line which is described by a very small magnetic needle, when it is so moved in either direction corre-

spondent to its length, that the needle is constantly a tangent to the line of motion; or, it is that line along which, if a transverse wire be moved in either direction, there is no tendency to the formation of an electric current in the wire, whilst if moved in any other direction there is such a tendency. The direction of these lines about and between ordinary magnets is easily represented in a general manner by the well known use of iron filings.

The method of recognizing and taking account of these lines of force which is proposed, and was illustrated by experiments during the evening, is to collect and measure the electricity set into motion in the moving transverse wire; a process entirely different in its nature and action to that founded on the use of a magnetic needle. That it may be advantageously employed, excellent conductors are required; and therefore those proceeding from the moving wire to the galvanometer were of copper 0.2 of an inch in thickness, and as short as was convenient. The galvanometer, also, instead of including many hundred convolutions of a long fine wire, consisted only of about 48 or 50 inches of such wire as that described above, disposed in two double coils about the astatic needle: and that used in the careful research contained only 20 inches in length of a copper bar 0.2 of an inch square. These galvanometers shewed effects 30, 40, or 50 times greater than those constructed with fine wire; so abundant is the quantity of electricity produced by the intersections of the lines of magnetic force, though so low in intensity.

The lines of force already described will, if observed by iron filings or a magnetic needle or otherwise, be found to start off from one end of a bar magnet, and after describing curves of different magnitudes through the surrounding space, to return to and set on at the other end of the magnet; and these forces being regular, it is evident that if a ring, a little larger than the magnet, be carried from a distance towards the magnet and over one end until it has arrived at the equatorial part, it will have intersected *once* all the external lines of force of that magnet. Such rings were soldered on to fitly shaped conductors connected with the galvanometer, and the deflections of the needle observed for one, two, or more such motions or intersections of the lines of force: it was stated that when every precaution was taken, and the results at the galvanometer carefully observed, the effect there was sensibly proportionate for small or moderate arcs to the number of times the loop or ring had passed over the pole. In this way, not only could the definite actions of the intersecting wire be observed and established, but also one magnet could be compared to another, wires of different thickness and of different substances could be compared, and also the sections described by the wire in its journey could be varied. When the wire was the same in length, diameter, and substance, no matter what its course was across the lines of force, whether direct or oblique, near to or far from the poles of the magnet, the result was the same.

A compound bar magnet was so fitted up that it could revolve on its axis, and a broad circular copper ring was fixed on it at the middle distance or equator, so as to give a cylindrical exterior at that place. A copper wire being made fast to this ring within, then proceeded to the middle of the magnet, and afterwards along its axis and out at one end. A second wire, touched, by a spring contact, the outside of the copper ring, and was then continued outwards six inches, after which it rose and finally turned over the upper pole towards the first wire, and was attached to a cylinder insulated from but moving round it. This cylinder and the wire passing through it were connected with the galvanometer, so that the circuit was complete; but that circuit had its course down the middle of the magnet, then outwards at the equator and back again on the outside, and whilst always perfect, allowed the magnet to be rotated without the external part of the circuit, or the latter without the magnet, or both together. When the magnet and external wire were revolved together, as one arrangement fixed in its parts, there was no effect at the galvanometer, however long the rotation was continued. When the magnet with the internal wire made four revolutions, as the hand of a watch, the outer conductor being still, the galvanometer needle was deflected 35° or 40° in one direction: when the magnet was still, and the outer wire made four revolutions as the hands of a watch, the galvanometer needle was deflected as much as before in the *contrary direction*: and in the more careful experiments the amount of deflection for four revolutions was precisely the same, whatever the course of the external wire, either close to or far from the pole of the magnet. Thus it was shewn, that when the magnet and the wire revolved in the same direction, contrary currents of electricity, exactly equal to each other, tended to be produced; that those outside resulted from the intersection by the outer wire of the lines of magnetic force external to the magnet; that wherever this intersection was made the result was the same; and that there were corresponding lines of force within the magnet, exactly equal in force or amount to those without, but in the contrary direction. That in fact every line of magnetic force is a closed curve, which in some part of its course, passes through the magnet to which it belongs.

In the foregoing cases the lines of force, belonging as they did to small systems, rapidly varied in intensity according to their distance from the magnet, by what may be called their divergence. The earth, on the contrary, presents us, within the limits of one action at any one time, a field of equal force.. The dipping needle indicates the direction or polarity of this force; and if we work in a plane perpendicular to the dip, then the number or amount of the lines of force experimented with will be in proportion to the area which our apparatus may include. Wires were therefore formed into parallelograms, inclosing areas of various extent, as one square foot, or nine square feet, or any other proportion, and being fixed upon axes equidistant from two of the sides could

have these axes adjusted perpendicular to the line of dip and then be revolved. A commutator was employed and associated, both with the galvanometer and the parallelograms, so that the upper part of the revolving wire always sent the current induced in it in the same direction. Here it was found that rotation in one direction gave one electric current; that rotation in the reverse direction gave the contrary current; that the effect at the galvanometer was proportionate to the number of rotations with the same rectangle; that with different sized rectangles of the same wire the effect was proportionate to the area of the rectangle, *i. e.* the number of curves intersected, &c. &c. The vicinity of other magnets to this magnet made no difference in the effect provided they were not moved during the experiments; and in this manner the non-interference of such magnets with that under investigation was fully established.

All these and other results are more fully stated and proved in papers now before the Royal Society. The general conclusions are, that the magnetic lines of force may be easily recognized and taken account of by the moving wire, both as to *direction* and *intensity*, within metals, iron or magnets, as well as in the space around; and that the wire sums up the action of many lines in one result: That the lines of force well represent the *nature, condition, direction*, and *amount* of the magnetic forces: That the effect is directly as the number of lines of force intersected, whether the intersection be direct or oblique: That in a field of equal force, it is directly as the *velocity*; or as the *length* of the moving wire; or as the *mass* of the wire: That the external power of an unchangeable magnet is *definite* yet illimitable in extent; and that any section of all the lines of force is equal to any other section: That the lines of force within the magnet are equal to those without: and that they are continuous with those without, the lines of force being closed curves.

[M.F.]

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In the Library, were exhibited:—

Portrait of Shakspeare (fac-simile in all but colour of the remains of a Portrait on Panel by his partner, Richard Burbage, 1597). [Presented by W. Nicol, Esq. M.R.I.]

*Whitworth's Surfaces*:—*i.e.* Two Iron Plates, the surfaces made so true by scraping, *not grinding*, that when one is placed on the other, they will not touch until the film of air between them becomes displaced by the weight of the upper plate. [Exhibited by Mr. J. G. Appold.]

Model of Appold's Centrifugal Pump. [Exhibited by Messrs. Watkins and Hill.]

Hodges' Power-Accumulators. [Exhibited by Mr. Hodges.]

Stereoscopes (on Brewster's principle) illustrating the Phœnomena of Binocular Vision, as explained by Professor Wheatstone. [Exhibited by Mr. Claudet.]
Talbotypes from the Great Exhibition, by Mr. Henneman.
A Telescopic Camera Lucida and a Microscope with improved Mechanism, by Mr. C. Varley.
Specimens illustrating Claussen's Processes of Preparing Flax, Hemp, &c. [Exhibited by Dr. Ryan.]
Minerals. [Exhibited by Mr. Highley, jun.]
Model (in similar materials) of the Lion, Bull, and Column from Nineveh in British Museum. [Exhibited with permission of Dr. Layard.]
Carving on wood by Mr. W. G. Rogers.

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## WEEKLY EVENING MEETING,

Friday, January 30.

W. R. Hamilton, Esq., F.R.S. &c. Vice-President, in the Chair.

Professor Brande,

*On Electro-Magnetic Clocks.*

Mr. Brande began by adverting to the various opinions which had been entertained in reference to the mutual relations of electricity and magnetism, previous to the grand discovery of Oersted in 1819. As soon as the influence of an electrical current upon a magnetic needle had been developed by the researches of that eminent philosopher, many most important applications of the fact almost of necessity suggested themselves, amongst which the wonders of the electric telegraph were to be included. Another result of Oersted's discovery was the *electro-magnet;* the power namely, of conferring by proper adjustments of an electric current any degree of magnetism upon a bar of soft iron: and inasmuch as these magnetic energies cease the moment that the electric current ceases, so we have it in our power to render any convenient form of soft iron, such as bars, or horse-shoes, powerful magnets at one moment, and at the next, entirely withdrawing all their powers; and this, simply by making and breaking the contacts upon which the flow of electricity from voltaic arrangement depends. In this way a horse-shoe magnet was made alternately to lift and drop a weight, to raise and depress a loaded lever, and to bend and release a spring. These effects were merely due to the attractive force of the electro-magnet upon holders and

bars of soft iron, with proper contrivances to prevent the interfering influence of the residuary magnetism which in such cases is more or less retained by the iron core of the coil. Another form of this application of electro-magnetism as a motive power consists in so arranging the electro-magnets that the poles may be alternately inverted, and so made to act upon adjacent permanent bar-magnets, both attractively and repulsively: these forms of the apparatus were also exhibited.

Mr. Brande then stated that upon examining Mr. Shepherd's electro-magnetic clocks at the Great Exhibition in Hyde Park, he had been especially struck by the excellent illustration which they afforded of the exclusive use of electro-magnetism as their moving power, its force being employed to give impulse to the pendulum, to propel the ordinary movement of the clock, and to effect the striking of the hour; no auxiliary weights or springs being in any case employed: and thinking the whole subject worthy the attention of the Members of the Royal Institution, had determined to bring it before them at one of their Friday Evening Meetings. He had therefore applied to Mr. Shepherd for such information and assistance as he required, and this had not only been cheerfully, but liberally given, Mr. Shepherd having furnished him with the pendulums, clocks, models, and diagrams, then before them, and with much useful information in reference to the whole subject.

Mr. Brande first explained the mechanism of the *pendulum*, which is so arranged as to make and break an electric circuit, and consequently to make and unmake a horse-shoe magnet at each vibration. Each time that the magnet is made it attracts its armature, which lifts certain levers: one of these is concerned in raising a weighted lever and causing it to be held up by a latch or detent; the magnet is then unmade in consequence of the pendulum breaking the circuit, and the armature is released, when the pendulum lifts the latch, and allows the weighted lever to fall, which, in falling, strikes the pendulum so as to give it an adequate impulse: then the circuit is again completed, the armature attracted, the levers moved, the weight raised, and held up by the detent; another vibration breaks the circuit and releases the armature; the pendulum then raises the detent, the weight falls, and in falling its arm strikes the pendulum, and gives it an impulse; and so on.

But the pendulum at each vibration not only makes and breaks the electric circuit of the battery which maintains its own action, but also, and simultaneously, that of a second battery, of which the duty is to make and unmake the electro-magnets belonging exclusively to the clock or clocks, which are upon this circuit. These electro-magnets act upon the extremes of one or more horizontal bar-magnets, so as alternately to attract and repel their opposed poles, and which carry upon their axis the pallets, by the alternating motion of which to the right and the left, the ratchet wheel is propelled onwards at

the rate of a tooth each second, and the axis of this ratchet wheel carries the pinion which moves the other wheels of the clock.

The circuit of the battery connected with the striking part of the clock is only completed once in an hour, and is connected with an electro-magnet so arranged, as by means of a proper lever to pull the ratchet wheel attached to the notched striking wheel one tooth forward every two seconds, and each tooth is accompanied by a blow on the electro-magnetic bell. The number of blows depends upon the notched wheel, the spaces on the circumference of which are adapted to the number to be struck, and when this is complete, a lever falls into the notch, and in so doing cuts off the electric current, which is not re-established through the striking electro-magnet, till the next hour, when a peg upon the hour wheel pushes the striking lever forward so as to cause it to be depressed by a similar peg upon the minute wheel.

Such is an outline of the mechanism of these clocks; but it is impossible to render further details upon the subject intelligible without reference to diagrams. A very large working model of the clock and of the striking apparatus, constructed for the occasion by Mr. Shepherd, was exhibited in the Theatre, as well as a model of the pendulum and its appendages made under the direction of Mr. C. V. Walker, to whom Mr. Brande was also indebted for a signal bell, upon the principle of Mr. Shepherd's clock bells, for the purpose of giving notice to the railway switchmen of the approach of trains in foggy weather.

Mr. Brande concluded by describing the arrangement of Mr. Shepherd's clocks as adopted in the extensive warehouse of Mr. Pawson in St. Paul's Churchyard, where eight dials are maintained in action by an electro-magnetic pendulum in the counting-house, and adverted to the Electric Clock at the Tunbridge Station of the South Eastern Railway, and to the intention of the Astronomer Royal to establish one at Greenwich for the purpose of sending time signals to the different Metropolitan Railway Stations, and to the Palace at Westminster.

[W. T. B.]

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In the Library were exhibited:

Wheatstone's Wave-line Apparatus. [Exhibited by Mr. Appold.]

Balæniceps Rex, the King Stork, from the Interior of North Africa, the property of Mansfield Parkyns, Esq. M.R.I.; and a Group of Humming-birds. [Mounted and Exhibited by Messrs. Leadbeaters].

Head of a Walrus from the Arctic Regions — a Mandingo Dagger — a Model of the Milk-yoke Knapsack, and other objects, from the United Service Institution.

**The Relational and Differential Slate, by Alfred Smee, Esq.**
**Specimens of Jewelled Porcelain [by Messrs. Copeland] and of French Flower-carving [by Mr. W. G. Rogers].**
**Models of Warming, Ventilating, Distilling, and Culinary Apparatus, by M. Andreoleti.**

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## GENERAL MONTHLY MEETING,

### Monday, February 2.

THE DUKE OF NORTHUMBERLAND, F.R.S., &c. President, in the Chair.

Bernard Edward Brodhurst, Esq. was *admitted* a Member of the Royal Institution.

Hewitt Davis, Esq.
Robert W. S. Lutwidge, Esq.
Right Hon. Baron Parke.
Alfred J. Woodhouse, Esq.

were duly *elected* Members of the Royal Institution.

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The following PRESENTS were announced; and the thanks of the Members returned for the same:—

FROM

*Agricultural Society, Royal* — Journal, Vol. XII. No. 2. 8vo. 1852.
*Asiatic Society, Royal* — Journal, Vol. XIII. Part 1. Vol. XIV. Part 2. 8vo. 1851.
*Asiatic Society of Bengal* — Journal, No. 222, 223. 8vo. 1851.
*Astronomical Society, Royal* — Monthly Notices, Vol. XII. No. 1. 8vo. 1851.
*Athenæum Club* — List of Members, &c. 1851
*Basel — die Naturforschende Gesellschaft* — Bericht, 1848-50. 8vo. Basel, 1851.
*Beke, C T., Ph. D. &c. (the Author)* — Enquiry into M. D' Abbadie's Journey to Kaffa to discover the source of the Nile. 8vo. 1851.
Summary of Recent Nilotic Discovery. 8vo. 1851.
On the Alluvia of Babylonia and Chaldæa. 8vo. 1851.
*Bell, Jacob, Esq. M.P. (the Editor)* — The Pharmaceutical Journal for January, 1852. 8vo. 1852.
*Brodhurst, Bernard E. Esq. M.R.I. (the Author)* — Of the Crystalline Lens and Cataract. 8vo. 1850.
*Buist, Dr. G. (the Author)* — Some Observations on the "Remarks of Commander Montriou." 8vo. 1851.
*Chemical Society* — Journal, No. 16. 8vo. 1851.
*Devincenzi, Signore Giuseppe (the Author)* — Discorsi, 8vo. Napoli, 1845.
Delle Strade Ferrate Italiane, &c. 8vo. Napoli, 1848.
*Editor* — The Athenæum for December 1851, and Jan. 1852. 4to.
*Ellis, Messrs., Exeter* — Map showing the Time kept by Public Clocks in various Towns of Great Britain, 1851.

*Faraday, Professor* — Monatsbericht der Königl. Preuss. Akademie. zu Berlin, Sept., Okt. 1851. 8vo.
*Franklin Institute of Philadelphia* — Journal, Vol. XXII. No. 2, 3, 4, 5. 8vo. 1851.
*Geographical Society, Royal* — Journal, Vol. XXI. 8vo. 1851.
*Glasgow, Philosophical Society of* — Proceedings, Vol. III. No. 3. 1850-1, 8vo. 1851.
*Hookham, Mr. T.* — The New Quarterly Review, No. 1. 8vo. 1852.
*Horticultural Society of London* — Journal, Vol. VII. Part 1. 8vo. 1852.
*Lovell, E. B, Esq. M.R.I., (The Editor)* — The Monthly Digest. December 1851, and January 1852. 8vo.
*Mackinnon, William A. Esq. M.P., F.R.S. (the Author)* — History of Civilisation and Public Opinion; 3rd Edition. 2 vol. 8vo. 1849.
*Museum of Practical Geology* — Introductory Discourses. 8vo. 1851.
On the Opening of the School, Nov. 6, 1851, by Sir H. T. De la Beche, C.B., F.R.S.
On the National Importance of Studying Abstract Science, &c. by Lyon Playfair, C.B., F.R.S.
On the Relations of Natural History to Geology and the Arts, by Edward Forbes, F.R.S.
On the Importance of Cultivating Habits of Observation, by Robert Hunt.
*Ryan, Dr. J.* — The Flax-Movement, &c. by the Chevalier Claussen. 8vo. 1851.
On Claussen's Flax-Cotton, by E. M'Dermott. 8vo. 1851.
Claussen's Specification. (Mech. Mag. No. 143.)
*Tilt, Edward John, M.D. (the Author)* — On the Diseases of Menstruation and Ovarian Inflammation. 12mo. 1850.
On the Preservation of the Health of Women at the Critical Periods of Life. 16mo. 1851.
*Turner, Thomas, Esq. (the Author)* — The Law of Patents and Registration of Invention and Design in Manufactures. 8vo. 1851.
*Twining, T. jun. Esq. M.R.I. (the Author)* — Notes on the Organisation of an Industrial College for Artisans. 8vo. 1852.
Jahrbücher des Vereins für Naturkunde im Herzogthum Nassau; Siebentes Heft. 8vo. Wiesbaden, 1851.
*Vereins zur Beförderung des Gewerbfleisses in Preussen* — Verhandlungen, Sept. und Okt. Berlin, 1851.
*Weale, John, Esq.* — Rudimentary Treatises. 12mo. 1851.
Clay Lands and Loamy Soils, by Professor Donaldson.
Descriptive Geometry (with Atlas, 4to.) by J. F. Heather, M.A.
Equational Arithmetic, by W. Hipsley.
Steam and Locomotion, by J. Sewell, L. E. Vol. I.
Art of Painting on Glass, from the German of Dr. M. A. Gessert.
Essay on the Art of Painting on Glass, from the German of E. O. Fromberg.
Art of Playing the Piano-forte, by C. C. Spencer.
*White, Walter, Esq. (the Author)* — Papers on Railway and Electric Communications, Arctic and Antarctic Explorations, and the Sanitary Movement. 12mo. 1850-1.
*Wilkinson, H. Esq., M. R. A. S. (the Author)* — Observations on Muskets, Rifles, and Projectiles. 12mo. 1851.
*Willich, C. M. Esq. (the Author)* — Annual Supplement to Tithe Commutation Tables, 1851. 8vo. 1852.
*Wrontchenko, M. le Comte, Ministre de Finance, Russie* — Annales de l' Observatoire Physique Centrale de Russie, 1848, Par A. Kupffer. 4to. 1851.
Compte Rendu Annuel, 1850. 4to. 1851.
*Wyld, J. Esq. M.P. (the Author)* — Notes on the Distribution of Gold throughout the World, &c. 8vo. 1851.

*H. W. Pickersgill, Esq. R.A.* — Portraits of Baron Cuvier, and Sir James Ross (Engraved from Paintings by himself.)
*Samuel Colt, Esq.* — American Revolving Pistol.

[FOR THE USE OF MEMBERS.]

# Royal Institution of Great Britain.

1852.

## WEEKLY EVENING MEETING,

Friday, February 6.

The Duke of Northumberland, F.R.S., President, in the Chair.

John Scott Russell, Esq., F.R.S.

*On Wave-line Ships and Yachts.*

The subject placed on the list for consideration this evening has been suggested by the assertion, which within a year or two has been so often repeated, that our Transatlantic brethren are building better ships than ourselves; that in short Brother Jonathan is going ahead, while John Bull is comfortably dozing in his arm-chair; and that if he do not awake speedily, and take a sound survey of his true position, he may soon find himself hopelessly astern.

Two questions of a practical nature arise out of this alarming assertion;— 1st, whether the Americans are really in any respect superior to the English in nautical matters; 2nd, whether in order to equal them we are to be condemned to descend into mere imitators, or whether we have independent ground from which we can start with certainty and originality on a new career of improvement in Naval Architecture?

In the outset I beg permission to say, that I am not one of those who shut their ears to the praises of our young and enterprizing brethren over the water, or view their rapid advancement with jealousy. It has been my good fortune to know some distinguished highly educated American gentlemen, philosophers, politicians, engineers, and ship-builders; men whom I should be proud to call Englishmen. I have for the last fifteen years been kept by them well informed of the progress of Steam Navigation in that country; and I beg therefore to express my perfect belief in the accounts we have heard of their wonderful achievements in rapid River Steam Navigation. I am satisfied, as a matter of fact, that 21, 22, 23 miles an hour have been performed, not once, but *often*, by their River Steamboats. To that we cannot in this country offer any parallel.

The next point in which they also had beaten us was in the construction of the beautiful Packet-ships, which carried on the passenger trade between Liverpool and America before the era of Ocean Steamers. These were the finest ships in the world, and they were mainly owned and sailed by Americans.

The next point at which we have come into competition with the

Americans has been lately in Ocean Steam Navigation. Three years ago they began: they were immeasurably behind us at starting; they are already nearly equal to us; their Transatlantic Steam-packets equal ours in size, power, and speed. In regularity they are still inferior. If they continue to advance at their present rate of improvement, they will very soon outstrip us.

Next I come to the trade which has long been peculiarly our own, the China trade. The Clipper ships they have recently sent home to this country have astonished the fine ships of our own Smiths and Greens. Our best ship-owners are now trembling for their trade and reputation.

Finally, it is true that the Americans have sent over to England a yacht called the America, which has found on this side of the Atlantic no match; and we only escaped the disgrace of her having returned to America, without any of us having had the courage to accept her defiance, through the chivalry of one gentleman, who accepted the challenge with a yacht of half the size, on this principle, so worthy of John Bull, "that the Yankee, although he might say that he had beaten us, should not be able to say that we had all run away."

Such then at present is our actual position in the matter of Ships, Yachts, and Steam Navigation, a position highly creditable to the Americans, and which deserves our own very serious consideration.

I propose to-night to examine a little into the physical causes of the naval success of the Americans; but before doing so, permit me to point out a moral one, which later in the evening you will also find to lie at the bottom of the physical causes. It is this; — John Bull has a prejudice against novelty; Brother Jonathan has a prejudice equally strong in favour of it. We adhere to tradition, in trade, manners, customs, professions, humours; Jonathan despises it. I don't say he is right and we are wrong; but this difference becomes very important, when a race of competition is to be run.

These preliminary remarks find immediate application in the causes which have led to our loss of character on the sea. The Americans, constantly on the alert, have carried out and applied every new discovery to the advancement of navigation; while with the English, naval construction and seamanship is exactly that branch of practice in which science has not only been disregarded, but is altogether despised and set aside. The American ships shew what can be done by modern science unflinchingly put in practice; the English shew what can be done in spite of science and in defiance of its principles.

The immediate cause of the defects of English ships, and the most glaring instance of the outrage of all true principle in the practice of navigation, was to be found for many years in the English Tonnage law. It was simply an Act of Parliament for the effectual and compulsory construction of bad ships. Under that law, the present fleet of merchant ships and of ship-builders has chiefly grown up, and though at length and only recently abrogated, its influence is still left behind and is widely prevalent. This Act

of Parliament compelled the construction of bad ships under heavy penalties. The old Tonnage law, according to which ships were built and registered and taxed and bought and sold, virtually said to the builder and owner, "Thou shalt not build a ship of the necessary beam to carry sail; Thou shalt not give her the depth and height necessary to security and sea-worthiness; Thou shalt not build her of any suitable shape for speed, under penalty of 20, 30, and 40 per cent of fine for every ton of freight so carried in such ship." In short the law offered a premium on a ship, the amount of which was in the proportion of her being wall-sided, top-heavy, crank, unweatherly, and slow: while it inflicted a penalty in the shape of port charges and all pilot, harbour dues, lights, &c. in proportion to her fitness and reputation as a sea-worthy, fast, and wholesome ship. To cheat the law, that is to build a tolerable ship in spite of it, was the highest achievement left to an English builder, and formed his continual occupation.

The manner in which the English system was opposed to the good qualities of a ship, especially speed, is only to be understood by an analysis of these qualities. The two examples selected for illustration of the qualities of sailing vessels, were — the yacht America, built without restriction of any kind, and the yacht Titania built under the restrictions of the law of measurement of Tonnage, which is still retained in all its deformity by the English Yacht squadron.

It was shewn how the element of "stand-up-ativeness" is dependent on the beam of the vessel at the water-line; how the power of carrying sail depends on this element, and how this element is prohibited to the utmost by the Yacht Club's law of Tonnage. Another element of the vessel, the area of her vertical longitudinal section immersed in the water, is by another portion of the law compelled to be reduced in an injurious degree. — It was next shewn that in the other elements of the form of the two vessels they were nearly identical; and that they were *both* under water constructed on the *Wave Principle* in its most perfect form. But for the existence therefore of these antiquated laws our yacht-builders and our ship-builders would have had nothing to fear from competition. Happily the mercantile Tonnage law had been altered and the new law was all that could be desired; and in consequence a new race of fast ships were rapidly springing up. The old Yacht law unhappily remained. It is peculiarly unfortunate, however, that the evils bad laws have done, do not die with them; and in this instance it has been found that when men have been trained for generations under a bad system, their prejudices remain too deep-rooted to achieve a sudden change of existence, and keep them in the deep and worn ruts of routine, by habits of thought and opinion almost inveterate. It is, however, to be hoped, that in the next ten years the English will escape from their prejudices, and that the rising generation will supply no unworthy competitors to their young and emancipated brethren on the other side of the water.

It appeared from the comparison which was instituted between the construction of American and English vessels, that the American

ship-builders have gained over the English chiefly by the ready abandonment of old systems of routine and the adoption of the true principles of science and the most modern discoveries. They have changed their fashions of steamers and ships to meet new circumstances as they arose. For River Steamers they at once abandoned all the known sea-going forms, and created an absolutely new form and general arrangement both of ship and machinery. We, on the other hand, subject to the prejudices of a class, invariably attempted to make a river steamer as nearly as possible to resemble a sea-going ship propelled by sails. We were even for a long time so much ashamed of our paddle-wheels, that we adopted all sorts of inconvenient forms and inapt artifices to conceal them, as if it were a high achievement to make a steam-vessel be mistaken for a sailing vessel.

The fine sharp bows which the Wave Principle has brought to our knowledge have been adopted in this country with the greatest reluctance, and those who adopt them are often unwilling to allow that they are wave-bows, and would fain assert that "they always built them so," were it not that ships' lines are able to speak for themselves. The Americans however adopted the wave-bow without reluctance, and avowed it with pleasure the moment they found it give them economy and speed. In like manner, the Americans having found the wave-bow or hollow bow good for steamers, were quite ready to believe that it might be equally good for sailing vessels. We on the other hand have kept on asserting that though we could not deny its efficacy for steamers it would never do for vessels that were meant to carry sail. The Americans on the contrary immediately tried it on their pilot-boats, and finding it succeed there, avowed at once, in their latest treatise on Naval Architecture, the complete success of the principle; not even disclaiming its British origin. To prove to ourselves our insensibility to its advantages — they built the America, carried out the wave principle to the utmost, and despising the prejudices and antiquated regulations of our Clubs, came over and beat us.

The diagrams and models which were exhibited shewed the water-lines of the America to coincide precisely with the theoretical wave line.

In one other point the Americans had shewn their implicit faith in science, and their disregard of prejudice. Theory says, and has always said, "Sails should sit flat as boards." We have said, "They should be cut so as to hang in graceful waves." It has always been so; we have always done it. The Americans believed in principle, and with flat sails went one point nearer to the wind, leaving prejudice and picturesque sails far to leeward.

In other points the Americans beat us by the use of science. They use all the refinements of science in their rigging and tackle; they, it is true, have to employ better educated and more intelligent men — they *do so;* and by employing a smaller number of hands, beat us in efficiency as well as in economy.

Faith in the value of Science, for the uses of practice, and a determination to carry it straight out with a total disregard of previous

prejudice, is the characteristic of American Naval Architecture and Nautical Practice. Disbelief in the power of prejudice and the virtue of routine is the principle which this example inculcates; and if it lead us to believe in science and our own judgment, and to emancipate ourselves from the trammels of prejudice grown old under unwise laws, and to cease from building ships by Acts of Parliament and Club laws, the recent victory of the America and the present victory of American Packet-ships will prove to have been benefits in disguise. [J. S. R.]

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In the Library, were exhibited:—

Model of the Yacht "America." [Exhibited by Mr. Scott Russell.]

Model of Apparatus for enabling a Ship's Company to take to the Boats simultaneously, and for the rapid disembarkation of Troops, by Julius Jeffreys, Esq. F.R.S., M.R.I., and Model of a Safety Boat Sling for a similar purpose, by Mr. Landells.

Model of a Brig with Revolving Masts, &c.—and Sculptured Windows from Akbar's Palace. [From United Service Institution.]

Models of Bones of Iguanodon, &c. and Impression of Labyrinthodon. [Exhibited by Mr. Tennant.]

Printing in Colours: L'Allegro, Il Penseroso, and View of Nottingham.—Portrait of a Child; and Walter and Jane, in Water Colours.—Portrait of Joseph Hume, Esq. M.P., in Crayons,—by Mr. C. B. Leighton.

Talbotype Portraits by Messrs. Henneman and Co.

Specimen of Pearl Enamelled Glass, and Jewelled Papier Maché. [Exhibited by Messrs. Allen.]

A Crozier, carved in wood, by Mr. W. Rogers.

Microscope by Mr. Varley.

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## WEEKLY EVENING MEETING,

Friday, February 13.

The Duke of Northumberland, F.R.S., President, in the Chair.

W. R. Grove, Esq., M.A., F.R.S.,

*On the Heating Effects of Electricity and Magnetism.*

In the early periods of philosophy when any unusual phenomenon attracted the attention of thinking men it was frequently referred to a preternatural or spiritual cause; thus with regard to the subject about to be discussed, when the attraction of light substances by rubbed amber was first observed, Thales referred it to a soul or spiritual power possessed by the amber.

Passing to the period antecedent to the time of more strict inductive philosophy, viz. the period of the Alchemists, we find many natural phenomena referred to spiritual causes. Paracelsus taught that the Archæus or stomach demon presided over, caused, and regulated the functions of digestion, assimilation, &c.

Van Helmont, who may be considered in many respects the turning point between Alchemy and true chemistry, adopted with some modification the Archæus of Paracelsus and many of the opinions of the Spiritualists, but shewed tendencies of a more correctly inductive character; the term 'Gas' which he introduced, gives evidence of the thought involved in it by its derivation from 'Geist' a ghost or spirit. By regarding it as intermediate between spirit and matter, by separating it from common air and by distinguishing or classifying different sorts of gas he paved the way for a more accurate chemical system.

Shortly after the time of Van Helmont lived Torricelli, who by his discovery of the weight of air was mainly instrumental in changing the character of thought and inducing philosophers to introduce, or at all events to develope the notion of fluids, as agents which effected the more mysterious phenomena of nature, such as light, heat, electricity, and magnetism.

Air being proved analogous in many of its characters to fluids as previously known, the idea of fluids or of an ether was carried on to other unknown agencies appearing to present effects remotely analogous to air or gases.

Sound was included by some in the same category with the other affections of matter, and as late as the close of the last century a paper was written by Lamarck to prove that sound was propagated by the undulations of an ether. Sound is now admitted to be an undulation or motion of ordinary matter, and Mr. Grove considered that what have been called the imponderables, or imponderable fluids, might be actions of a similar character, and might be viewed as motions of ordinary matter.

Heat was at an early period so viewed, and we find traces of this in the writings of Lord Bacon. Rumford and Davy gave the doctrine a greater development, and Mr. Grove in a communication made by him at an Evening Meeting of this Institution in 1847, shewed that what had hitherto been deemed stumblingblocks in the way of this theory of heat, viz. the phenomena presented by what have been called latent and specific heat, might be more simply explained by the dynamic theory.

In this evening's communication he brought forward some experiments and considerations in favour of the extension of this view to electricity and magnetism, an extension which he had for many years advocated, and which was, in his opinion, supported by many analogies.

The ordinary attractions and repulsions of electrified bodies present no more difficulties when regarded as being produced by a change in the state or relations of the matter affected, than did the attraction of the earth by the sun, or of a leaden ball by the earth; the hypothesis of a fluid is not considered necessary for the latter, and need not be so for the former class of phenomena.

In the cases of heating or ignition of a conjunctive wire or conducting body through which what is called Electricity is transmitted, we have many evidences that the matter itself is affected, and in some cases temporarily, in others, permanently changed; thus if a wire of lead is ignited to fusion by the voltaic battery, the fused lead being kept in a channel to prevent its dispersion, it gradually shortens, and the molecules seem impressed with a force acting transversely to the line of direction of the electricity; at length the lead gathers up in nodules which press on each other as do, to use a familiar illustration, a string of figs.

With Magnetism we have many instances of the molecular change which a ferreous or magnetic substance undergoes when magnetized. If the particles are free to move, as for instance iron filings, they arrange themselves symmetrically. An objection may be made arising from the peculiar form of the iron filings, but Mr. Grove in the year 1845, shewed that the supernatant liquid in which magnetic oxide had been formed, and which contains magnetic particles not mechanically but chemically divided, exhibits when magnetized a change in the arrangement of the molecules, as may be seen by its effect on transmitted light; — a molecular change is also evidenced by the note or sound produced by magnetism, and by other effects.

Assuming that the molecules of iron change their position *inter se* upon magnetization, then by repeated magnetization in opposite directions, something analogous to friction might be produced; and just as a piece of caoutchouc when elongated produces heat, (as it was on this occasion experimentally shewn to do) so a bar of soft iron might be expected when subjected to rapid changes in its magnetic state, to exhibit thermic effects.

With the aid of the large magnet of the Institution and of a commutator for changing the direction of the Electricity a bar of soft iron was alternately magnetized in opposite directions; and in a few minutes a thermometer placed in an aperture in the iron shewed a rise of temperature of 1, 5° Fahrenheit; the bar being separated from the magnet by flannel, and the magnet being at a notably lower temperature than the bar, this heat could in nowise be attributed to conduction.

The effect of Electricity in the disruptive discharge as in the Voltaic arc and the electric spark, would seem at first sight to offer greater difficulties of explanation on the dynamic theory. The brilliant phenomenal effects of the electric discharge, and the apparent absence of change in the matter affected by it, would at first lead the observer to believe that Electricity was a specific entity.

With ordinary flame or the apparent effects of combustion however, the idea has to a great extent been abandoned that such visual effects are due to specific matter, and it is regarded by many as an intense motion of the particles of the burning body. So with Electricity, if in regard to the disruptive discharge it can be shewn that the matter of the terminals or of the intervening medium is changed, the necessity for the assumption of a fluid or ether ceases, and, to say the least, a possibility of viewing Electricity as a motion or affection of ordinary matter is opened.

To make evident to the audience the relation of the electrical discharge to combustion and the fact that the terminals were themselves affected, the Voltaic arc was taken, first between silver and then between iron terminals; in the first case a brilliant green coloured flame was produced, and in the second a reddish scintillation or spur fire effect, just as in the ordinary combustion of the metals.

So with the discharge of Franklinic Electricity between the same two metals, a strip of silvered leather gave the bright green discharge, while a chain of iron gave the spur fire effect.

The known transport of particles of the terminals from one pole to the other,— the different effects of different intervening media on induction as shewn in Faraday's experiments,— the polar tension of such media, &c. were instances of the train of molecular changes consequent upon electrical action.

Hitherto the polarity of the gaseous medium existing between the metallic or conducting terminals of the electrical circuit was only known as a physical polarity and not shewn to have an analogous chemical character with that existing in electrolytes anterior to electrolysis; but Mr. Grove stated that in a recent communication to the Royal Society he had shewn that mixtures of gases having opposite electrical or chemical relations, such as oxygen and hydrogen, or compound gases such as carbonic oxide, were electro-chemically polarized or had their electro-negative and electro-positive elements thrown in opposite directions: thus if a silvered plate be made positive in such gases it is oxidized, if negative the dark spot of oxide is reduced; and an experiment was shewn in which such a plate was thus oxidized and the spot reduced in gaseous media.

Here, as in the other experiments, was an effect on the terminals and an effect of polarization of the intermedium. In the experiments hitherto shewn, solid terminals were used; it became important to examine what would be the effect of liquid terminals, for instance water; the spark or disruptive discharge of Franklinic Electricity was readily obtained from its surface, but hitherto no voltaic battery had been found to shew a discharge at any sensible distance from the surface of water.

Mr. Gassiot had procured to be constructed 500 cells of the nitric acid battery, the combination discovered in 1839 by Mr. Grove and first shewn at this Institution in the year 1840. The cells of this battery were all well insulated by glass stems, and as regards intensity of action it was probably far the most powerful ever seen. Mr. Gassiot had kindly lent this apparatus for the illustration of this evening's discourse, and by its aid Mr. Grove was able to shew an experiment which he had first made when experimenting with Mr. Gassiot some time ago, and which produced the effect he had long sought for, viz. a quantitative or voltaic discharge at a sensible distance from the surface of water. The experiment was made as follows: — a platinum plate forming the anode of the battery was immersed in a capsule of distilled water, the temperature of which was raised. A cathode or negative terminal of platinum wire was now made to touch for a moment

the surface of the water and immediately withdrawn to a distance of about quarter of an inch; the discharge took place, the extremity of the platinum wire was fused and the molten platinum attached to the wire but kept up by the peculiar repulsive effect of the discharge was exhibited, as it were, suspended in mid-air, giving an intense light, throwing off scintillations in directions away from the water and only detaching itself from the wire when agitated.

Here water in the vaporous state must be transferred, for the immersed electrode gave off gas, without doubt oxygen, and the molecular action on the negative fused platinum resembled, if it were not identical in character with the currents observed on the surface of mercury when made negative in an electrolyte.

It may be objected to the theory proposed, that electrical effects are obtained in what is called a vacuum, where there is no inter-medium to be polarized; but this objection, though not applicable to the projection of the terminals, could hardly be discussed until experimentalists had gone much further than at present in the production of a vacuum; the experiments of Davy and others had shewn that we are far off from obtaining any thing like a vacuum where delicate investigations are concerned.

The view of the antient philosophers that Nature abhors a vacuum which had been much cavilled at, and was supposed to be exploded by the discovery of Torricelli, Mr. Grove thought had been unjustly censured: giving the expression some degree of metaphorical license, it afforded a fine evidence of the extent and accuracy of observation of those who were unacquainted with inductive philosophy as a system, but who necessarily pursued it in practice. Whether a vacuum was possible might be an open question, experimentally it was unknown.

Lastly, in answer to those who might ask, to what practical results do researches such as these lead? what accession of physical comfort or luxury do they bring? Mr. Grove took occasion to offer his humble protest against opinions now perhaps too generally prevalent, that science was to be viewed only or mainly in its utilitarian or practical bearings. Even regarding it in this aspect, were it not for the devotion which the love of knowledge, which the yearning anxiety to penetrate into the mysteries of our being and of surrounding existences induced; the practical results of science would not have been attained; the band of Martyrs to Science from Socrates to Galileo would not have thought and suffered without a higher incentive than the acquisition of utilitarian results: without disparaging these results, indeed regarding them as necessary consequences of any advance in scientific knowledge, he considered that the love of truth and knowledge for themselves was the great animating principle of those who rightly pursued science; that, based upon an enduring quality of our common nature, this feeling was rooted in far firmer foundations, that it led to greater and more self sacrificing exertions, than any capable of being induced by the hopes of augmenting social acquisitions, and was an attribute and an evidence of the non-transient part of our being.

[W. R. G.]

In the Library were exhibited: —

Native Salts from Tarapaca, Peru, presented by W. Bollaert, Esq.
Crystals of Meconic Acid, Morphia, &c. [Exhibited by T. N. R. Morson, Esq. M.R.I.]
Specimens of Harmotome, and Calc Spar Crystals. [Exhibited by Mr. Highley, jun.]
Spanish Terra Cottas; and a Drawing after Lucca di Robbia, by Mr. W. G. Rogers.
Porcelain Vessels for Chemical Purposes, from the South of France. [Exhibited by W. T. Copeland, Esq.]
Minié's Projectiles, used by the Chasseurs of Vincennes. [Exhibited by J. Prosser, Esq.]
Native Gold from California — Green Carbonate of Copper — Carbonate of Lime, &c. [Exhibited by Mr. Tennant.]
Microscope by Mr. Varley.

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## WEEKLY EVENING MEETING,

Friday, February 20.

The Duke of Northumberland, F.R.S., &c. President, in the Chair.

Mr. F. C. Penrose,

### *On some Relations of Science to Architecture considered as a Fine Art.*

Scientific considerations not only apply to the Constructive in Architecture, but also to its æsthetic element.

Science was defined by the Lecturer as "the knowledge which is derived in the first instance from the observation of natural phenomena aided by reflection upon the results of such observation," and he classed under the head of Science, so defined, all careful considerations of the analogy of Nature and Art.

In all the most perfect works of art the economic and æsthetic ends are answered together. Illustrations were drawn from the beauty of the tapering shaft of a Greek column, which with the same amount of material has more stability than if cylindrical; and from the graceful form of the Eddystone lighthouse, of which the contour was chosen chiefly with reference to the form of greatest resistance.

The perception of beauty is an innate idea implanted in man by his Creator, and the only really perfect examples are to be looked for in Nature; but the highest works of art may come so near perfection that we can propose no material change which would not more or less injure their beauty. The most important lesson which can be learnt from a careful examination of Nature is that no design is perfect until the utmost attainable utility is combined with the

ghest degree of beauty, neither quality at all interfering with the :her. We further learn that humble buildings should be simple nd subordinate to, but not irrespective of, the more noble; that hese should exhibit order and symmetry, but should differ among hemselves in Character; efficiency rather than beauty to be looked for in absolutely concealed construction, but ugliness scarcely to be tolerated under any circumstances in features exposed to the eye. The mere rule "Decorate the useful," although good as far as it goes, is inadequate, for the beauty should be a function of the use, and the use of the beauty.

The Lecturer proceeded to inquire in what Styles of Architecture are found the best illustrations of the application of Scientific principles to æsthetic ends, — *i. e.* for the elaboration of beautiful form: observing with reference to the conventional rules which form the grammar (as it were) of each particular style, that these rules were subordinate to principles founded on science and common sense;— that their object was to prevent confusion and ignorant caprice, and were made for the use of the architect and not for his embarrassment.

The Architecture of Greece alone exhibits satisfactory evidences of the application of Science to Fine Art. The Romans actually gloried in the abnegation of the highest aims of art, and no peculiar refinements were to be found in their Architecture, even after the most diligent examination. The Architecture of the thirteenth century, with all its beauties, is so overrun with curious fancies, whether arising from carelessness or symbolism, that the abnormal varieties, which in Greek Architecture point out a principle, are in this style, in the majority of instances, mere caprice, as far at least as art is concerned.

Alberti and Brunelleschi, and the great masters who revived classical art, who so wonderfully succeeded in adapting an ancient Architecture to the uses of their day, and who formed out of it a living style unshackled by timid retrospection, do not seem to have used any peculiar refinements; neither do their chief followers in this country, Inigo Jones and Sir Christopher Wren. Palladian Architecture having fallen into feeble hands was, in this country, ejected by an ill-digested importation of Greek Architecture, to which it did not do justice, either in respect of artistic or of scientific treatment; but it chiefly failed from overlooking the proper use to which the Architecture of the Greek temple should be applied by us.

"It should be proposed as a standard of excellence, as an abstract model for our guidance, and not as one suitable for direct imitation."

The Architecture now in fashion is treated in a manner scarcely less retrospective than the last mentioned, and great as are its intrinsic excellencies, is peculiarly unplastic and opposes itself to the exhibition of mechanical power or scientific refinement.

The late attempts to revive Greek Architecture were much hampered by a feeling of the necessity of carrying symmetry to an extreme which is not found in the original.

A natural type of the picturesque Gothic Architecture may be found in the varied landscape, and of the Greek, in the symmetries of the animal creation; but as in Nature animals, abstractedly symmetrical, are thrown into varied postures and groups, so the Greek Architect used the principle of *asymmetria* in his ichnography; that is, in his ground plan he avoided placing one building directly before another, and turned the lines of those which were independent of each other to different points of the compass,—thus obtaining variety in perspective, fine gradations of light and shade, and an expression of individual character among the buildings themselves. This principle was illustrated by a plan of the Acropolis of Athens.

In this irregular oblong figure, extending from West to East, the point fixed by the nature of the ground, is the Western Entrance where the Propylæa stand. The Parthenon placed near the centre and highest portion of the area, but towards the Southern edge of the rock, is so turned as to offer an angular view from the Propylæa. The latter building being dependent on the Parthenon, its lines are built parallel to those of that temple, and so serve by repetition to increase the effect of the principal object; especially in the general views from the West, when the Parthenon is seen above the Propylæa. At the same time their axes do not coincide, but that of the Propylæa falls altogether to the North of the Parthenon. The Erechtheum, the building of second importance, is placed a little North of the axis of the Propylæa, and is turned obliquely with respect to it, at such an angle as to show its South side distinctly. The colossal statue of Minerva Promachus, stood Eastwards of the Propylæa, and nearly in the direction of its axis, at a distance of about 120 ft. The pedestal of this statue again was placed somewhat obliquely, and there are several platforms at different points and at various levels, which served (there is little doubt) as foundations for small temples, which converge towards the statue of Minerva Promachus, thus producing every variety of angle. And lastly, the small temple of Nike Apteros on the platform of the Propylæa, and to the West, is placed at an angle differing by 18° from parallelism with it.

The Erechtheum, a small building, and the Propylæa are complex in their forms, but the Parthenon (neglecting minute variations) is rigidly symmetrical. In large buildings the effect of perspective introduces sufficient variety. One of the greatest sources of pleasure in Architecture, is the act of reconstructing mentally the real form from an image modified by perspective. That this may be possible—the square and rectangles simply related to it, and the circle should predominate in the ground plan, however much it may be desirable to use more varied parallelograms, the ellipse, or figures of greater variety in the Elevation, which may be seen from the proper point of view almost unaffected by perspective.

The Greek Doric temple is the one form of building ancient or modern which can be pronounced, humanly speaking, perfect. This perfection resulted from the concentrated efforts of several ages. Not by introducing violent changes after each experiment, and so

throwing aside all advantage to be derived from them, but by continually improving them by the application of a scientific and refined criticism.

The early temple consisted of an oblong cella, the shrine of the god, surrounded by a Peristyle, or colonnade, usually leaving an ambulatory all round the cella. This composition was covered by a single roof from end to end, with a triangular pediment, or flat gable end, at each extremity. In the latest and most complete examples we find the simple general form preserved, but combined with a highly organized construction. The most important peculiarities are these. The contours of all the columns are delicate curves. The axes of the columns, with scarcely an exception, inclined inwards towards the temple, and the horizontal lines have a slight curvature.

The process of refinement would seem to be as follows: —

The analogy of nature in all bodies which are employed to exert force or pressure at a distance from their attachment to a fixed point, would soon suggest the practice of making the columns taper. The earliest builders would indeed find this done to their hands in the trunks of trees, which found a place in the supports of the hut, more or less the archetype of the Greek temple. It would then be observed that a column built with straight sides, *i. e.* tapering as the frustum of a cone, would appear attenuated or drawn in in the middle — owing to the eye not judging of the form absolutely as an instrument, but bringing into the calculation certain feelings derived from contrast, which make the apparent differ from the real form.

The causes which lead to this apparent attenuation seem to be chiefly these: —

There is some reason for imagining that a frustum of a very sharp cone will under any circumstances appear formed of concave instead of straight sides, but this effect, if it take place at all, will be very slight: other causes however affecting such a frustum when used as a column are more influential.

The eye will rest longer upon the top and bottom of the shafts than on any intermediate points, and this relative importance possessed by those situations will make the intermediate diameters appear too small, when compared with the two extremities of the shaft.

This effect will be further increased by inequalities of chiaro-oscuro. For the relative excess of light on the upper part, owing to the deep back ground of shade under the Portico, and the actual excess on the base owing to the greater amount of reflected light, will throw the balance of light in favour of the extremities, and according to a principle familiar to observers of Nature the brighter parts will appear broader on that account. Among the most obvious illustrations of this phenomenon are the apparent disc of a fixed star; the magnified appearance of a distant candle; the sudden appearance of dilation in the disc of the moon when issuing from a fleecy cloud, or its opposite appearance of stooping on entering it, so poetically described by Milton. From all these, and possibly

other causes united, the tapering shaft of the column will appear attenuated, unless its contour be made just so much convex, as to counterbalance these optical illusions. This entasis as it is called, literally *bow-stretching*, as applied in the columns of the Parthenon is formed by an accurate hyperbolic curve, which increases the diameters a little below the middle by the amount of .114 ft. in a shaft 31.4 ft. long. The directions of the axes of this hyperbola are vertical and horizontal; the constant number which expresses the eccentricity is 30; and the principal axis one Greek foot; the vertex does not occur in the shaft and is just two diameters of the column below the base.

The columns of the Propylæa are also hyperbolic, but differ from the last mentioned, in that the vertex of the hyperbola occurs near the middle.

When this difference had been pointed out by measurement, the variation of character resulting therefrom to the two columns became appreciable; but in all the Athenian examples the entasis is so slight, that the first investigators of the remains of Greek architecture, whose eyes were accustomed to the palpable bulging of the columns built by the architects of the 16th and 17th centuries, were deceived by its delicacy, and reported that the Greek columns had no entasis.

Table of Entasis of different columns at Athens.

| | Actual measurement in Feet. | In terms of length of Shaft. |
|---|---|---|
| Erechtheum | .0195 | $\frac{1}{1080}$ |
| Theseum | .023 | $\frac{1}{708}$ |
| Parthenon | .057 | $\frac{1}{552}$ |
| Propylæa | | |
| Small order | .0343 | $\frac{1}{500}$ |
| Large order | .0627 | $\frac{1}{400}$ |

The entasis being established, a second process of refinement would lead to the inclination of the axes of the columns.

The diminution is so entirely in conformity with Nature, that the artifice more or less escapes observation, and the upper diameter does not appear so much smaller than the lower as it really is. This circumstance may combine with the others before mentioned, to demand the entasis, but it immediately produces the effect which the inclination of the columns seeks to remedy. For by how much so ever the sum of the upper diameters is apparently increased, by so much is the appearance of length in the architrave greater than in the stylobate (or step on which the columns stand), and the columns appear to have a fan-like divergence from the base line, unless the length of the architrave be reduced. This was effected by the Greeks by contracting the distance between the capitals of the extreme intercolumniations. This contraction in the Parthenon produces an inclination of .228 ft. in the angle columns in each direction, entailing a parallel inclination inwards in all the intermediate columns of each colonnade. Several subordinate inclinations

in the other vertical lines are exhibited in the following table taken from the Parthenon, and the other Athenian examples are more or less analogous.

| | | | | |
|---|---|---|---|---|
| Columns . . . . . . | inwards | 1 | in | 150 |
| Walls . . . . . . | do. | 1 | in | 80 |
| Face of Tympanum . . | do. | 1 | in | 100 |
| Antæ . . . . . . . | forwards | 1 | in | 80 |
| Faces of Cornice . . . | do | 1 | in | 100 |
| Faces of Acroteria . . | do. | 1 | in | 20 |

The horizontal lines when absolutely straight appeared sunk in the middle. In the great temple at Pæstum, the convexity which is intended to obviate this effect is only found in the fronts; and in the Propylæa at Athens, where the continuity of the stylobate is interrupted, the curvature is only found in the entablature, the centre columns being longer than those towards the angles; thus pointing to the influence of the raking lines of the pediment as the origin of this optical illusion. The curvature of the stylobate and of the flanks followed from the generalization of this idea. This tendency of the eye to be deceived by the contrast of lines, was illustrated by the following experiments: —

A drawing having been prepared of two columns placed side by side, the shafts of which were formed with perfectly straight lines, on each side of these, and from top to bottom, the lecturer drew a flat circular arc, convex to the outline of one of the columns, and concave to the other. The column placed between the two concave lines instantly seemed attenuated, whilst in the other, about which the convex lines were drawn, the effect of a palpable entasis was produced. An outline of a pediment had also been provided, consisting of the horizontal cornice and the two inclined roof lines. The cornice was at first alone visible, and appeared perfectly straight, as it really was, but when the raking lines of the pediments which had been concealed were shown in combination, it appeared to sink in the centre. Lastly an elevation of the front of the Parthenon drawn to a scale of one-twentieth of the full size, from exact measurements obtained at Athens, was exhibited. The line of the cornice, really curved, appeared to be straight, owing to the contrast of the inclined lines of the pediment, until a string was strained from end to end, when the curvature became evident.

The lecturer proceeded to describe some of the smaller details of the architecture, in which many instances of geometrical science are to be found.

The parabola and hyperbola selected with the parameters at the vertex, small in comparison with the length of the arc employed, were used in almost all cases where great variety of curvature was sought. There were even some indications of a knowledge of the determination of the radius of curvature in a Conic Section.

A moulding of circular section was used in the Parthenon only in the crowning member or Cymatium.

It was observed that lines of determinate varied curvature were preferable to those arbitrarily drawn, and still more to patched

combinations of the arcs of different circles, in which each circle seemed always struggling to express its own curvature, and discordant with the sequence of the general line.

In conclusion the lecturer said that the object of the architect should be to study what the Greeks and other real advancers of art achieved, and to extend their principles by embodying as much as possible the science of the day.

It was not the curved lines or the use of the Conic Sections in the mouldings which produced their excellence, but because they pursued art in the right way; they availed themselves of whatever methods would obviate the optical illusions which impaired the beauty of their architecture, and of whatever geometrical figures would in the most simple manner give them the determinate varied curves in which they delighted.

Several instruments for drawing curves by continued motion invented by the Lecturer also were exhibited: one for drawing the hyperbola by means of a variable triangle, with a constant base sliding on the asymptotes of the curve. (The same instrument would also draw the conchoid of Nicomedes.) An instrument on the principle of a skeleton cone for drawing all the conic sections — and an instrument for drawing the Cissoid of Diocles, with variations of that curve; Penrose and Bennett's registered Helicograph for drawing all the varieties of the equiangular spiral from the circle to the straight line. A specimen of its operation was shewn in a drawing of an Ionic capital, after the Erechtheum; and a simple instrument invented by Mr. Jopling for drawing a fine wave, or line of beauty, by means of the curve *lemniscata*, and an oblique elliptic trammel, made from a pattern proposed by the same inventor.

[F. C. P.]

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In the Library were exhibited: —

Instruments used in Measuring the Parthenon; and Sketches of Athens, &c. by Mr. F. C. Penrose.

"The Principles of Athenian Architecture, by F. C. Penrose, Esq." Presented by the Society of Dilettanti.

Talbotype Views of the Parthenon, Athens, &c. by Messrs. Henneman and Co.

Geometric Curves and Apparatus used in drawing them, with description by Mr. Joseph Jopling. [See "An Impulse to Art; and Examples of Entasis," &c. 8vo. 1849, by Mr. Jopling, presented by him to the Library, R. I.]

Specimens of Glass Mosaic, by Mr. G. H. Stevens.

Models of Smoke-Consuming Furnaces, &c. by Messrs. Juckes, Addams, and Coupland.

Model of Galloway's Tubular Boiler. [Exhibited by Mr. Armstrong.]

Sepulchral Seals and other Antiquities, from the United Service Institution.

A Painting on Marble, by Paul Brill. [Exhibited by Mr. H. Brooke.]

Dies and Medals, by Mr. G. Barclay.

[FOR THE USE OF MEMBERS.]

# Royal Institution of Great Britain.

1852.

## WEEKLY EVENING MEETING,

Friday, February 27.

THE DUKE OF NORTHUMBERLAND, F.R.S. President, in the Chair.

DR. LYON PLAYFAIR, C.B., F.R.S.

*On three important Chemical Discoveries from the Exhibition of 1851 — A. Mercer's Contraction of Cotton by Alkalies; — B. Young's Paraffine and Mineral Oil from Coal; — C. Schrötter's Amorphous Phosphorus.*

[The following statements and arguments were supplied by DR. LYON PLAYFAIR as embodying considerations which he desired to impress on the attention of the Members of the Royal Institution.]

IT is incumbent on those who, like myself, have been connected with the Great Exhibition, to inculcate its teachings in order that it may influence the future, by being a starting point for industry. Unless it imparts new life to productive industry, it has failed in the attainment of its object, and will, in history, degenerate into the record of a gigantic show, fitted only to pander to an idle curiosity. All of us have, no doubt, examined it with a higher object, and have derived lessons varying in character and amount according to the opportunities which we enjoyed in their acquisition. Those who have attended to its teachings with regard to the comparative progress of manufactures in different countries, owe it as a public duty to announce their convictions on a subject of such large social importance.

My official connection with the Exhibition has enabled me to give more attention to it than most of those whom I have the honour to address, and convictions unfavourable to our position, as an industrial nation, have impressed themselves with such force upon my mind, that you will not be surprised that I seize every opportunity of directing public attention to them. I have already done so in a formal manner, on two previous occasions, and I rather depart from the custom of bringing before you subjects of original research at these evening meetings, in order that I may advocate the necessity of a more intimate union between science and practice in this country, at an Institution, whose proudest boast it is to have largely advanced the discovery of abstract truths, while it has always encouraged, at the same time, their applications to the increase of human resources and enjoyments.

In this lecture, however, I shall rather urge this point as a natural

consequence of the subjects chosen for illustration of my argument than by any doctrinal exhortations, because these are not needed to strengthen your general convictions.

Our nation has acquired a proud position among the industrial states of the world, partly by the discoveries of her philosophers, partly by the practical powers and common sense of her population, but chiefly by the abundance and richness of her natural resources. Our fuel is abundant and cheap, and our iron and the lime necessary for its production are associated with it, so that all three may be extracted together under the most favourable circumstances. These local advantages gave to our country enormous powers of production, and, under the favouring influences of an accidental combination, it supplied its produce to the rest of the world. Circumstances remaining the same, our industrial position was secured, and we have been thus lulled into a fatal apathy; for conditions were in fact varying with great rapidity, and the world at large was passing through a state of remarkable transition.

Setting aside the questions of capital and labour, which are not adapted for discussion in this place, the progress of manufactures is made up of two factors, possessing very different values. One of these represents the raw produce,—the other, the intellect or science employed to adapt it to human wants. As civilization advances, the value of the raw material as an element of manufactures diminishes, while that of the intellectual element is much enhanced. Improvements in locomotion by sea and land spread over the world the raw material formerly confined to one locality; and a time arrived when a competition of industry became a competition, not of local advantages, but of intellect.

It was obvious that when improved locomotion gave to all countries raw material at slight differences of cost, that any superiority in the intellectual element would more than balance the difference. The Continental States, acting on a perception of this truth, saw that they could only compete with English industry by instructing their populations in the principles of science. Hence have arisen, in their capitals, in their towns, and even in their villages, institutions for affording a systematic training in science; and industry has been raised from the rank of an empirical art to that of a learned profession. The result is seen in the fact that we now meet most European nations as competitors in all the markets of the world. The result is palpably forced upon us by our actual displacement from markets in which we had a practical monopoly. The result was obvious in the Exhibition, where we saw many nations, formerly unknown as producers, frequently approaching, and often excelling us in manufactures, our own by hereditary and traditional right.

The teaching of the Exhibition was to impress me with the strongest conviction that England, by relying too much on her local advantages, was rapidly losing her former proud position among manufacturing nations; and that unless she speedily adopted measures to cultivate the intellectual element of production, by instructing her population in the scientific principles of the arts which they

profess, she must inevitably and with rapidity lose those sources of power, which, in spite of the smallness of her home territory, have given to her so exalted a rank among nations.

With these convictions you will not be surprised that I have chosen subjects connected with the Exhibition, although I have no merit or part whatever in their discovery. I have selected them for the following reasons.

We have a great reliance on the practical sagacity or common sense of our population,—certainly superior to that of any part of Europe: but we have not strengthened it by communicating scientific knowledge to those who are entrusted with the exercise of this practical power; and, hence, this common sense, unaided by the rules of science, has gradually assumed a sway over our manufactures. In other words, conjectural judgments have usurped the place of systematic knowledge. Practice and science have been followed out separately, as having no immediate connection. This separation, and even practical antagonism, has been fatal to our progress in industry; for manufacturers, as a body, have ceased to perceive that abstract science forms the roots of the tree of industry, and that to separate them is to sever the tree from its roots. In order to restore vigour to our declining industry, it is essential that confidence in the powers of science should be imparted to practice, and that the latter should be taught that it is, even as a question of social policy, highly important to encourage discoveries in abstract truths, however apparently remote from practice; because science only benefits industry by its overflowings, arising from the very fulness of its measure.

Every abstract truth, in its due time, adds to human resources and enjoyments, and it is this text that I wish to inculcate from examples derived from the Exhibition. One of the last generalizations of the great Berzelius, was that of *allotropism*, a name only eleven years old, and fully explained by him only six years since; and yet this generalization, apparently, at the time, only of abstract interest, entirely remote from practical application, produced as fruit the three most original, and, I think, the most important, practical discoveries of the Exhibition.

Having thus introduced the subject of his Lecture, Dr. Playfair proceeded to offer certain examples of *allotropism*. It had long been known that bodies crystallized in two or more incompatible forms. Thus, carbonate of lime as arragonite crystallizes in prisms; whereas as calcareous spar it crystallizes in rhombs. Sulphur also crystallizes in two incompatible forms; so does the garnet. This is termed *dimorphism*. When two such forms exist they are found to be maintained in unequal stability; it appears, in fact, as if one form was normal and the other forced or strained. Thus a prism of arragonite is subject to change into rhombs of calc spar; and sulphur crystallized by heat in oblique rhombic prisms passes in a few days into a mass of rhombic octohedrons. Not only may the chemical and physical characteristics of such dimorphous bodies

differ, but their colour and their specific gravity. Thus, the sulphuret of iron (Fe. $S_2$), when crystallized in cubes, is persistent in the air; but when occurring in a rhombic form, readily passes into copperas or sulphate of iron.

Applying the preceding remarks to non-crystallized bodies, it was equally found that many were susceptible of allotropic modification. Thus cinnabar and vermilion were of precisely similar chemical composition with the black sulphuret of mercury. Again, the sesqui-sulphuret of antimony might be black or orange. Iodide of mercury is commonly red; when heated, however, it passes into a yellow powder, which by simple pressure and rubbing with a hard body becomes red again. Sugar is a remarkable instance of a solid capable of assuming two allotropic states; as sugar candy it is crystallized, as barley sugar it is amorphous; yet the composition of sugar in either case is the same. Nor are liquids exempt from the strange state of allotropism,—sometimes indeed manifesting a condition even beyond allotropism (*isomerism*), and not allowing us to reconvert them to their primitive state. Thus the chemical composition of oil of turpentine, of rosemary, of lemons, of copaiba, are identical, yet no one of these bodies has hitherto been turned into the other. The steroptane of otto of roses is identical in composition with coal gas, yet chemists are unable to change one into the other. The term isomerism has been commonly employed in relation to bodies of like atomic composition, and has reference to equality of parts. The term allotropism is a better denomination, and has reference to the condition of unlike properties.

The preceding remarks by Dr. Playfair were introductory to an exposition of the respective discoveries of Mr. Mercer, Mr. Young, and Dr. Schrötter.

A.—Mercer's process consists in bringing cotton fabrics in contact with a solution of soda (cold), or a solution of dilute sulphuric acid, by subjecting it to either of which processes cotton acquires certain remarkable properties. In the first place, the texture becomes very much corrugated, and hence proportionably finer; it also assumes acid properties, rendering it more capable of taking up dyes. The process of induction which led Mr. Mercer to his final discovery was curious. He started from the point of investigating the laws which determined the flow of water at various temperatures through minute tubes. From water he proceeded to aqueous saline solutions; from tubes he proceeded to their equivalent, namely, closely-folded woven tissue. Selecting for this purpose a thick reduplication of calico, fold on fold, and employing an aqueous solution of soda, Mr. Mercer found that, by passing the solution through the calico, soda was removed. This removal he attributed to the act of filtration; but, subsequently finding that mere immersion of the calico in the same solution effected a like result, he concluded that the result was due to an actual combination of the cotton with the soda—a calico-*ate* of soda (if the lecturer might be permitted that form of expression) was generated.

The result of this agency of soda was, as formerly remarked, a physical corrugation, and an acquisition of certain chemical qualities. The former change was evident to the eye. Dr. Playfair exhibited two stockings, one of which being nearly double the size of the other, although both came equal in size from the loom. The difference had been occasioned solely by chemical not mechanical agency. Dr. Playfair, in developing the numerous practical applications of this physical effect, showed that, besides the most obvious one of producing a material of increased fineness, the cotton thus prepared was far more capable of being dyed. Hot soda solution would not answer; and this fact was remarkable and had its analogue in those salts which deposited themselves anhydrous on boiling. Instead of soda sulphuric acid might be employed; in which case it formed, in combination with the cotton fibre, an easily decomposable conjugate acid.

B.—Some years ago Liebig stated that one of the greatest discoveries of chemistry would consist in converting coal-gas into a solid form, thus enabling it to be burned like a candle. This had, in a manner, been accomplished by Mr. Young. About three years since, Dr. Playfair drew the attention of Mr. Young to a spring of mineral oil, containing paraffine, and occurring in a coal-mine in Derbyshire. The liquid had been extensively applied by Mr. Young as a lubricating agent; a use which Reichenbach had long ago suggested. After a period, however, this spring ceased to flow, when Mr. Young applied himself to an investigation of the theoretical conditions under which it might be artificially formed. This gentleman saw that it would be difficult to convert gas into an allotropic form, whereas it was evident that gas must first come from a solid; hence he hoped to succeed in procuring the body before it assumed its gaseous state.

The illuminating portion of coal gas consists chiefly of olefiant gas, and the latter is isomeric with solid paraffine. But the allotropism does not end here; the peculiar slow distillation of coals yielding solid paraffine, also yielded another isomeric or allotropic compound in the form of a lubricating oil, besides the additional products of a burning oil, and naphtha.

Dr. Playfair now explained, by the aid of a diagram, the slow distillation process of Mr. Young, employed in generating his allotropic form of olefiant gas, and directed the attention of his audience to some candles made of coal paraffine on the lecture table.

C.— Schrötter's process of manufacturing amorphous or allotropic phosphorus was the third in Dr. Playfair's series. The properties of phosphorus in its ordinary condition are well known. It is spontaneously inflammable and highly poisonous; whereas the amorphous or allotropic phosphorus is neither spontaneously inflammable nor poisonous. Hence its great use in the manufacture of lucifer and congreve matches; an operation which not only imperilled the premises wherein it is conducted, but also the lives of those conducting it, causing the most frightful and fatal disease of the jaws and facial bones.

Common phosphorus, when heated to about 460 or 480, changes

into the allotropic condition, but a slight increment of heat changes it back again. Hence the manufacture of this substance on a large scale is attended with difficulties which Dr. Playfair had no doubt would be eventually overcome by the energy of Mr. Sturge the patentee. The specific gravity of ordinary phosphorus is 1.77 — of amorphous phosphorus, 1.964. Common phosphorus is soluble in bi-sulphuret of carbon, whereas the amorphous variety is not. Common phosphorus bursts into flame when brought into contact with iodine, whereas the amorphous or allotropic variety does not. Common phosphorus is luminous at very low temperatures, whereas the amorphous variety only commences to be luminous at a temperature of 500° F. In forming lucifer matches by means of allotropic phosphorus, there is experienced the difficulty that it does not ignite by friction; hence it has to be mixed either with chlorate of potash, oxide of lead, or sulphuret of antimony, when friction takes effect and generates flame.

Having thus discussed the experimental portion of his lecture, Dr. Playfair concluded as follows: —

These three practical discoveries, for I think they are entitled to be considered as such, and not merely as inventions, have emanated from men all highly educated in chemical science. It is a proud subject of praise and of congratulation, that the two first discoverers, Mr. Mercer and Mr. Young, have, by the aid of science, raised themselves from the position of working artizans to that of employers in works involving considerable capital in their prosecution. Science has been to them a true power, the more so as in the arts which they profess, the manufacturers have usually been men of technical and not of scientific knowledge. The very fact of their success is a convincing evidence of what an immense development our industry might receive, if its sons were able to take advantage of the knowledge which science is constantly showering down upon the world.

There is a wide chasm between the laboratory of the philosopher and the workshop of the manufacturer — a chasm which must be bridged over by those who understand the nature of the foundations on either side. In general it is not the duty of the philosopher to do this; it is more important for social progress, that he should continue to benefit the world by new accessions of truth, leaving to others to apply them to the promotion of the comforts and happiness of the human race. If technical men become disciples of science, then their acquaintance with the wants and requirements of manufacturers would enable them to derive from its teachings the knowledge requisite to apply it to the desired ends. Science should roll on, as it does now, a mighty river, from the abundant waters of which streams may be derived to fertilize the lands over which they pass; for in the course of nature, these overflowings are restored in the form of refreshing showers. Their beneficial effects will however depend upon the skill of those who

construct the channels destined to direct the waters for the uses of industry.

It is no new truth that science should always be ready to benefit industry by instructing those engaged in it, rather than by directly uniting with it. This truth is as old as the mythology, where we find no celestial so beneficent to industrial arts as Minerva, although she always preserved an independent existence, notwithstanding the passionate wooing of Vulcan, the god of industry. We have had it inculcated by the sages of all countries, strongly enforced by our own Bacon, and eloquently advocated in the theatre of this Institution by Davy.

Abstract science could not, if it would, cause itself and industry to progress satisfactorily by means of its discovering philosophers. There must be other means of conveying its God-born truths to industry, in order to freshen and invigorate its existence. The results of continental success indicate that the true way for those requiring aid is to come to the fountain of knowledge and take that which they need.

I need not detain you longer on this subject, except again to urge you to consider what must be the result of the system of instruction pursued abroad. In addition to many provincial schools, France has two central colleges of arts and manufactures, in one of which 300 of the best youth of France commence their education in science just where our colleges leave off, and after two years, they are poured into the provinces to impart to industry the principles of science which they have there attained. Prussia, Austria, Russia, and the Northern States are encouraging the same kind of education, and even yet more extensively. Need we be surprised, then, that they are progressing so rapidly in manufactures, in spite of their dear fuel and machinery. Recollect that we *have* reached that state when in future the *competition of industry must be a competition of intellect*.

Is England in a prepared state to meet this intellectual competition? Have we adapted the system of instruction in our schools to the wants and necessities of the age? Has science, or a knowledge of God's works and God's goodness and wisdom, yet become an important part of the instruction of our sons of industry, or, do we not, by an antiquated notion, preserve the idea that the classical learning of the thirteenth century is all-sufficient for the requirements of the nineteenth century?

These questions are truly important if we desire to see England keep her ground in the industrial struggle of nations. I wish not to underrate any branch of human learning; but I do vehemently desire to see banished from our schools the bed of Procrustes, to the dimensions of which our children are clipped or extended until they are so changed in their natural aspirations for science, that it is very difficult, in after life, to communicate that amount which is necessary for its application to industry. I need not say, therefore, that until scientific instruction be added to the general system of education of our youth, that England cannot expect to be foremost in the industrial race of nations.

Already we see our capital largely employed to import foreign talent into our manufactures, and by this, in many cases, we retain our superiority. But it does not require much acumen to perceive the wretchedness of this policy as regards the nation, which, careless of the education of her own sons, sends her capital as a premium to the advancement of that intellectual knowledge in foreign states, who use it as the means of her destruction.

Excuse me if I have expressed my convictions on these points more strongly than you feel them; but they have taken such strong hold on my mind, that I cannot see safety for the future of our nation unless by a great and comprehensive improvement in the instruction of her people. I shall conclude in the language of Davy, when he addressed you on the benefits conferred by this Institution both on science and on industry: —

"There is no country which ought so much to glory in the progress of science as this happy island. Science has been a prime cause of creating for us the inexhaustible wealth of manufactures; and it is by science that it must be preserved and extended. We are interested as a commercial people; we are interested as a free people. The age of glory of a nation is also its age of security. The same dignified feeling which urges men to gain dominion over nations, will preserve them from the dominion of slavery. Natural, and moral, and religious knowledge are of one family; and happy is the country, and great its strength, where they dwell together in union." [L. P.]

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In the Library were exhibited: —

Specimens of Corals and Madrepores; Iodide of Morphia, Gadolinite, and Sulphate of Strychnia. [Exhibited by T. N. R. Morson, Esq. M.R.I.]

Specimens of Fossil Wood from eight different strata, and a Sword from Assam. [Exhibited by Dr. Roxburgh, M.R.I.]

Large Stereoscopic Talbotype Views of the Interior of the Great Exhibition by Wheatstone's Improved Reflecting Stereoscope. [Exhibited by Mr. Henneman.]

Views of the Interior of the Great Exhibition, and of the Niagara Falls — and Portraits of Professors Brande and E. Forbes, Dr. Mantell and others, Daguerreotyped by Mr. Mayall.

Chinese Carving in Tree-Roots — Dog and Monkey. [Exhibited by Mr. Sichart.]

Nassau Candelabrum in Silver by Messrs. Hunt and Roskell.

Carvings in Wood, — Dead Larks — Group of Dead Animals — Cherub's Head in Box-wood, by Mr. W. G. Rogers.

Gems: Diamonds — A Large Emerald, (the property of the Duke of Devonshire) — Sapphire, Topaz, &c. — and a Model of the Koh-i-noor. [Exhibited by Mr. Tennant.]

Models of Moore's Patent Glass Ventilator, by Messrs. Moore.

Drawing in Water Colours — Hall Sands, Devon, by G. Barnard, Esq.
Microscopes by Messrs. Varley.

In the Ante-room were exhibited: —

A Model of a Martello-tower, near Genoa, constructed for the Drawing Classes at Rugby School, by Mr. G. Barnard, from Sketches made on the spot; and Drawings made from the Model by his Pupils.

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## GENERAL MONTHLY MEETING,

Monday, March 1, 1852.

Sir John P. Boileau, Bart., F.R.S., Vice-President, in the Chair.

Samuel Gaskell, Esq.
Alfred James Woodhouse, Esq.
Robert S. W. Lutwidge, Esq.

Were *admitted* Members of the Royal Institution.

J. G. Appold, Esq.
Rev. J. Brownbill.
Octavius Browne, Esq.
George Edward Dering, Esq.
George Field, Esq.
Matthew Flower, Esq.
Lieut.-Colonel Francis Vernon Harcourt.
Thomas Henry, Esq.
Abel Jenkins, Esq.
Francis Lloyd, Esq.
Charles Lyall, Esq.
Kenneth Macaulay, Esq., Q.C.
George Whitlock Nicholl, Esq.
Rev. C. Pritchard, M.A., F.R.S.
Samuel Tomkins, Esq.
Edward Owen Tudor, Esq.

Were duly *elected* Members of the Royal Institution.

The Secretary reported that the following Arrangements had been made for the Lectures after Easter, viz.: —

Eight Lectures on the History and Practice of Sculpture, by R. Westmacott, R.A.

Eight Lectures on the Physiology of Plants, by Dr. E. Lankester, F.R.S.

Six Lectures on Points connected with the Non-Metallic Elements — by Professor Faraday.

The following Presents were announced; and the thanks of the Members returned for the same: —

From
*Astronomer-Royal.* — Astronomical and Magnetical and Meteorological Observations at Greenwich in 1850. 4to. 1852.

*Astronomical Society* (*Royal*) — Memoirs, Vol. XX. 4to. 1851.
Monthly Notices, Vol. XI. 8vo. 1851., and Vol. XII. No. 2 & 3. 8vo. 1852.
*Bell, Jacob, Esq. M.P.* (*the Editor*) — The Pharmaceutical Journal for Feb. 1852.
*Botfield, Beriah, Esq., F.R.S., F.S.A., M.R.I.* (*the Editor*). — Original Letters relating to the Ecclesiastical Affairs of Scotland, 1603 — 1625. 2 vols. 4to. 1851.
*Institute of British Architects* (*Royal*). — Proceedings, Feb. 1852. 8vo.
*Institute of Civil Engineers* — Proceedings, Feb. 1852. 8vo.
*Commissioners in Lunacy* — Sixth Annual Report. 8vo. 1851.
*Society of Dilettanti* — An Investigation of the Principles of Athenian Architecture, &c., by F. C. Penrose, Architect, M.A. Folio. 1851.
*Editor* — The Athenæum for Jan. 1852. 4to.
*Editor* — The Chemical Record for February, 1852. 8vo.
*Faraday, M. Esq.* (*the Author*) — Experimental Researches in Electricity. 28th Series. 4to. 1852.
Kaiserliche Akademie zu Wien: *Phil.-Hist. Classe*: —
Denkschrifte, 2te Band, 2te Abtheilung. 4to. 1851.
Sitzungsberichte, 6te Band und 7te Band, Heft 1 und 2. 8vo. 1851.
Die Alterthümer vom Halstätter Salzberg: von F. Simony. obl. fol. 1850.
Archaelogischen Analecten, von Joseph Arneth. obl. fol. 1851.
*Math.-Nat. Classe*: —
Denkschrifte, 2te Band, 3te Abtheilung. 4to. 1851.
Sitzungsberichte, 6te Band und 7te Band, 1te und 2te Hefte. 8vo. 1851.
Archiv für Kunde Œster. Geschichts-Quellen, 5te Band, 3te und 4te Hefte; und 6te Band. 8vo. 1850-1.
Fontes Rerum Austriacarum, 4te Band. 8vo. 1851.
Notizenblatt, No. 2 — 18. 8vo. 1851.
Atti dell' Academia Ponteficia de Nuovi Lincei, Anno IV. Sess. 5, 6. 4to. 1851.
Monatsberichte der Königl. Preuss. Akademie zu Berlin, Nov. und Dec. 1851. 8vo.
*Geological Society* — Quarterly Journal, No. 29. 8vo. 1852.
*Jopling, Joseph, Architect* (*the Author*) — An Impulse to Art, or Ancient Greek Principles for Volutes, &c. and Examples of Entasis. 8vo. 1848-9.
*Lawson, H., Esq., F. R. S.* — The Thermometer-Stand. 8vo.
*Lovell, E. B., Esq., M. R. I.* (*the Editor*) — The Monthly Digest. Feb. 1852.
*Manning, F., Esq., M.R.I.* — Account of the Kenilworth Buffet with elaborately carved relievos, illustrative of Kenilworth Castle in the Elizabethan Period, designed and manufactured by Messrs. Cookes and Sons, Warwick, for the Grand Exhibition of 1851. 4to. 1851.
*Newman, Mr. J.* — Instructions for using Newman's Standard and Portable Barometers and Daniell's Hygrometer. 8vo. 1845-52.
*Neale, Edward Vansittart, Esq., M. R. I.* (*the Author*) — "May I not do what I will with my own?" Considerations on the Present Contest between the Operative Engineers and their Employers. 12mo. 1852.
*Prince, C. Leeson, Esq.* (*the Author*) — Results of a Meteorological Register kept at Uckfield, Sussex, for 1851.
*Statistical Society of London* — Journal, Vol. XIV. Part 4. 8vo. 1852.
*Vereins zur Beförderung des Gewerbfleisses in Preussen* — Verhandlungen, Nov. und Dec. 1851.
*Vincent, B.* (*Assist. Sec. R. I.*) — Histoire de la Guerre de Sept Ans en Allemagne de 1756 à 1763, par M. J. W. D'Archenholtz: traduite de l'Allemand, par M. D'Arnex. 12mo. Berne, 1789.
The North American and West Indian Gazetteer. 12mo. 1776.

*Bollaert, W. Esq.* — Specimens of Native Salts from Tarapaca, Peru.

## WEEKLY EVENING MEETING,

Friday, March 5.

W. R. HAMILTON, Esq. F.R.S., F.S.A., Vice-President, in the Chair.

GIDEON ALGERNON MANTELL, Esq., LL.D., F.R.S.,
President of the West London Medical Society, &c.

*On the Structure of the Iguanodon, and on the Fauna and Flora of the Wealden Formation.*

THE geological phenomena of the South-East of England, comprising the lithological characters and organic remains of the Diluvial, Tertiary, Cretaceous, Wealden, and Oolitic deposits, were described in two Lectures delivered to the Members of the Royal Institution by Dr. Mantell in 1836 and 1849. In those discourses the Fauna and Flora of the *Wealden* were cursorily noticed, and the Iguanodon and other gigantic terrestrial reptiles, whose fossil remains have invested the strata of Tilgate Forest with a high degree of interest, were briefly alluded to. The present Lecture was restricted to a consideration of the Fauna and Flora of the countries whence the deposits constituting the Wealden districts were derived; and the osteological characters of the most remarkable fossil Saurians peculiar to this geological epoch, were especially illustrated.

After a concise exposition of the characters of the various formations which have succeeded, and now overlie, or in other words, are of more recent origin than the Wealden, — namely, the *Drift* or Diluvium, containing bones of large mammalia, as the Mammoth, Mastodon, Rhinoceros, Horse, Deer, &c;—the *Eocene*, or ancient tertiary strata of the London basin, abounding in marine exuviæ of special and for the most part extinct types;—and the *Cretaceous* or Chalk-Formation, comprising the White-Chalk of the North and South Downs, and the Chalk-marl, Galt, and Greensand, of Surrey, Kent, and Sussex, the whole characterized by innumerable marine shells, zoophytes, fishes, reptiles, &c. of extinct species and genera; — Dr. Mantell proceeded to illustrate the structure of the Iguanodon as exemplified by the isolated parts of the skeleton hitherto discovered, and of which numerous examples were exhibited on the tables of the Institution.

The perfect germ, and the unused tooth, of the Iguanodon, are characterised by the prismatic form of the crown, which is traversed on the thick enamelled face by three or four longitudinal ridges, and has the lateral margins denticulated, and the summit finely crenated; in this state the teeth resemble those of the living *Iguana* of the West Indies, — a resemblance which suggested the generic name of *Iguanodon*. But the fossil teeth are of enormous size in comparison with their recent prototypes; for the teeth of the Iguana are as

small as those of the mouse, while those of the Iguanodon are often one inch wide, and three inches in length. Specimens exhibiting the above characters are however, rare; the summit of the crown is usually more or less worn away by use, and the fang removed by absorption from the pressure induced by the upward growth of the successional teeth. In the first example discovered by Dr. Mantell (in 1820), the crown was ground down so as to present on its inner face a smooth oblique surface with a cutting edge on the summit, and the marginal crenations were worn away; in this state the fossil so strikingly resembled an upper tooth of a Rhinoceros, that Baron Cuvier pronounced it to belong to a species of that genus. Numerous teeth in different stages of growth and detrition were at length obtained, and the reptilian character of the animal to which they belonged was satisfactorily determined. Three years since, the first specimen of the lower jaw was discovered by Captain Lambart Brickenden, in the same quarry in Tilgate Forest from which the earliest known tooth was obtained; and subsequently a portion of the upper jaw with teeth has been procured from the Hastings' strata.

Referring to his various Memoirs on the Iguanodon in the Philosophical Transactions, and to his recent work on the Organic Remains in the British Museum,* for details, the Lecturer stated that while the compound structure of the lower jaw, and the mode of dentition, established the reptilian character of the original animal, the maxillary organs presented a nearer approach to those of certain mammalia, than is observable in any other reptiles. The teeth in the upper and lower jaw were arranged in a sub-alternate order as in ruminants; the face of the crown, or that having the thickest coat of enamel, is placed mesially or on the inner side of the lower teeth, and on the external surface of the upper. The anterior part of the lower jaw is edentulous, and its symphysial extremity forms a scoop-like process, which resembles the corresponding part of the inferior jaw of the Edentate mammalia, as for example the *Mylodons:* and the great number and size of the vascular foramina of the jaw indicate a greater development of the lips, and integuments, than occurs in any existing animals of the class Reptilia; the sharp ridge bordering the deep groove of the symphysis, in which there are likewise several foramina for the exit of nerves and blood-vessels, evidently gave attachment to the muscles and integuments of the lip: while two deep pits for the insertion of the protractor muscles of the tongue, manifest the mobility and power of that organ. There are therefore strong reasons for supposing that the lips in the Iguanodon were flexible, and in conjunction with the long fleshy prehensile tongue, were the chief instruments for seizing and cropping the leaves, branches, and fruit, which from the construction of the teeth we may infer constituted the food of the original. The mechanism of the maxillary organs as eluci-

* "Petrifactions and their Teachings, or a Hand-book to the Gallery of Organic Remains of the British Museum," one vol. 1851, published by H. G. Bohn.

dated by recent discoveries is thus in perfect harmony with the remarkable characters which rendered the first known teeth so enigmatical: and in the Wealden herbivorous reptile we have a solution of the problem, how the integrity of the type of organization peculiar to the class of cold-blooded vertebrata was maintained, and yet adapted, by simple modifications, to fulfil the conditions required by the economy of a gigantic terrestrial reptile, destined to obtain support from vegetable substances: in like manner as the extinct colossal herbivorous Edentata, which flourished in South America, countless ages after the country of the Iguanodon and its inhabitants had been swept from the face of the earth.

The structure of the cervical, dorsal, and caudal vertebræ, of the ribs, the pectoral and pelvic arches, the sacrum formed of six anchylosed vertebræ, the bones of the extremities, and certain dermal appendages, were successively described, and illustrated by drawings and specimens. From the facts adduced Dr. Mantell infers that this stupendous reptile equalled in bulk the largest herbivorous mammalia, and was as massive in its proportions; for living exclusively on vegetables, the abdominal region must have been greatly developed. Its limbs were of proportionate size and strength, to support and move so enormous a carcass; its length, as proved by recent discoveries, was of crocodilian proportions, for there is no doubt that the tail was very long; and the largest Iguanodon may have attained a length of from fifty to sixty feet.

The *Hylæosaurus*, *Megalosaurus*, and several other genera of reptiles were severally noticed, and reference made to the specimens in the British Museum. The *Pelorosaurus* was next described somewhat in detail, and the characters of the stupendous humerus, or arm-bone, ($4\frac{1}{2}$ feet long), scapula, clavicle, vertebræ, sacrum, and pelvis, were pointed out, with the view of illustrating a most interesting discovery made but a few days previously by S. H. Beckles, Esq. of St. Leonard's.

With much labour and skill, Mr. Beckles had succeeded in extracting from a block of Wealden sandstone lying on the Sussex coast, and which was only visible at low-water, the perfect *radius* and *ulna* (bones of the fore-arm), and *humerus* (arm-bone), of a gigantic reptile, which Dr. Mantell pronounced to be a *new species of Pelorosaurus*, and proposed to name *Pelorosaurus Becklesii*. The generic identity and specific difference between this humerus and that of the *Pel. Conybeari*, which was placed beside it, were pointed out, and the remarkable modification of structure presented by the *ulna* was explained. The arm-bone of the *P. Conybeari* is 54 inches long, the corresponding bone of a Gavial or gangetic Crocodile 18 feet long, in Dr. Grant's Museum, is but $11\frac{1}{2}$ inches; the humerus discovered by Mr. Beckles is $22\frac{1}{2}$ inches in length, and the bones of the fore-arm are 16 inches long. A portion of the scaly cuirass which covered the limbs and is composed of hexagonal plates, was exhibited.

The Lecturer then took a rapid view of the other reptiles that were contemporary with the Iguanodon, enumerating the *Pterodactyles* or

flying lizards, and several genera of Crocodilians and Chelonians. Examples of marine and fresh-water turtles are not uncommon in the Wealden deposits; and the strata near Swanage have furnished many beautiful specimens to the researches of Mr. Bowerbank.

Of *Fishes* there are nearly forty known species in the Wealden, which are chiefly referable to the *Ganoid* and *Placoid* orders. The fishes most abundant in the rivers of the Iguanodon country were two or three species of *Lepidotus*,—ganoids closely allied to the *Bony* or *Gar-Pike* of America; their teeth and scales are everywhere to be met with in the Tilgate strata.

The *Invertebrate Fauna* comprised many genera of *Insects*, a few *Crustaceans*, and numerous fresh-water *Mollusca*. The *Insects* (for a knowledge of which we are mainly indebted to the scientific acumen of the Rev. P. Brodie) amount to several hundred specimens, comprising between thirty and forty families or genera, and are referable for the most part to the orders *Coleoptera*, *Orthoptera*, *Neuroptera*, *Hemiptera*, and *Diptera*. Among them are several kinds of Beetles, Dragon-flies, Crickets, May-flies, and other familiar forms which are closely allied to species that inhabit temperate climates.

*Mollusca*. The most numerous shells belong to the genera *Cyclas* and *Paludina*; of the latter, which is a genus of fresh-water snails, there are a few species that abound in the Wealden Clays and Purbeck beds, and form extensive strata of shelly limestone, the compact masses of which are susceptible of a good polish and are well known by the names of Sussex, Petworth, and Purbeck Marble; the latter was in great request in the medieval ages, and is the material of which numerous tombs and monuments, and cluster columns in our ancient Cathedrals are constructed. Two common inhabitants of our pools and streams, the Planorbis and Limneus, also occur. Several species of *Unio*, some of which rival in magnitude the pearl-mussels of the Ohio and Mississippi, likewise abound in the Wealden deposits. Fresh-water Entomostraceans, *Cyprides*, of several species, swarm in many of the clays and iron-stone beds of Sussex and the Isle of Wight.

The Flora of the country of the Iguanodon appears to have been as rich and diversified as the Fauna. Forests of *Coniferæ*, referable or closely allied to *Abies*, *Pinus*, *Araucaria*, *Cupressus*, and *Juniperus*, clothed its hills and plains: with these were associated arborescent and herbaceous Ferns, comprising upwards of thirty species; together with many *Cycadeaceæ*, and trees allied to the *Dracæna*, *Yucca*, *&c.* Equistaceous and Lycopodiaceous plants also abounded; and even the common inhabitants of our streams, the *Charæ*, flourished in the rivulets of that marvellous region.

As examples of the vegetation of the Wealden period, Dr. Mantell described the petrified forest of coniferæ and cycadeæ in the Isle of Portland: the accumulation of fossil firs and pines exposed on the southern shore of the Isle of Wight; and the coal-field of Hanover, which entirely consists of the carbonized foliage,

trunks, and branches, of coniferous trees, drifted from the country of the Iguanodon.

The facts thus rapidly noticed prove that during the deposition of the Wealden, Oolitic, and Cretaceous strata, there existed an extensive Island or Continent, diversified by hills and valleys, and traversed by streams and rivers teeming with fishes, crustaceans, and mollusca, closely allied to types which at present inhabit the fresh-water of temperate regions; and that with these were associated fluviatile turtles, and crocodilian reptiles, whose living analogues are restricted to tropical climes. Colossal herbivorous and carnivorous saurians, differing essentially in structure from all known existing forms, were the principal inhabitants of the dry land; and these, together with flying lizards, and possibly a few birds, and very small mammalia, constituted the vertebrate fauna of the country, or countries, which supplied the materials of the Wealden strata, and of the fluvio-marine deposits which are intercalated with the purely oceanic beds of the Oolite and Chalk.

Thus it appears, according to the present state of our knowledge, that the classes Mammalia and Aves, which constitute the essential features of the terrestrial zoology of most countries, were represented through a period of incalculable duration solely by two genera of very diminutive mammals, and a few birds; while the air, the land, and the waters, swarmed with peculiar reptilian forms, fitted for aerial, terrestrial, and aquatic existence.

Admitting to the fullest extent the effect of causes that may be supposed to have occasioned the absence of mammalian remains in the secondary deposits, yet the immense preponderance of the reptile tribes is unquestionable. Some authors have attempted to account for this anomaly by assuming that antecedently to the Eocene Period, our planet was not adapted for the existence of mammalia, in consequence of its atmosphere being too impure to support higher types of animal organization than the cold-blooded vertebrata. But the certainty that some forms of marsupial and placental mammalia inhabited the countries of the Megalosaurus and Pterodactyle, — that birds in all probability existed with the Iguanodon, — and the fact that insects and mollusca, and trees and plants, which now inhabit regions abounding in birds, and mammalia, flourished during the "Age of Reptiles,"— demonstrate that the physical conditions of the earth, and the constitution of the atmosphere, and of the waters, differed in no essential respect from those which now prevail, and that the laws which govern the organic and inorganic kingdoms of nature have undergone no change.

That the class Reptilia was developed during the periods embraced in this discourse to an extent far beyond what has since taken place appears to be indisputable; nor can any satisfactory solution of the problem be offered from the data hitherto obtained. Future discoveries may however show that coeval with the country of the Iguanodon there were regions tenanted by birds and mammalia; and that the almost exclusively reptilian fauna of the lands whose zoological and botanical characters have formed the

subject of this Lecture, was but an exaggerated condition of that state of the animal kingdom which is exhibited by the present fauna of the Galapagos Islands.*

In conclusion Dr. Mantell alluded to the recent discovery of reptilian remains (the *Telerpeton Elginense*, and the presumed Chelonian foot-tracks') in the Old Red Sandstone of Morayshire,† in proof of the necessity of bearing in mind the salutary caution of Sir Charles Lyell, "that as our acquaintance with the living creation of past ages must depend in a great degree on what we term chance, we ought never to assume that the first creation of any type of animals or plants took place at the precise point where our retrospective knowledge happens to stop."

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In the Library were exhibited: —

Section of Bones of the Iguanodon, shewn by the Microscope. [Exhibited by A. J. Woodhouse, Esq. M.R.I.]

Drawing of the Notornis Mantelli, by Mr. Gould, and Drawings of the Iguanodon by J. Martin, Esq., R.A., &c. [Exhibited by Dr. Mantell.]

Fossils from the Coal-pits, Lesmahago, Scotland, presented by Captain Inglefield.

Portrait of Mrs. S. C. Hall by D. Maclise, and Frame carved by Mr. W. G. Rogers.

Specimens of Sussex and Purbeck Marbles. [Exhibited by Mr. C. H. Smith.]

Otter, Fox, and Cocks of the Rock, from Brazil and California, and Apteryx Australis, — mounted by Messrs. Leadbeaters.

Tazza with Engraving, "Nature," after Lawrence — Vases inlaid with specimens of Marbles, &c. and Bronzes. [Exhibited by Mr. Tennant.]

Manganese Oxyd and other Minerals. [Exhibited by Mr. Highley, jun.]

Specimens of Chasing in Silver, by Mr. Higgins.

Models of the Steam-Engines of Savery, Newcomen, and of Watt. [Exhibited by Mr. Addams.]

The Circulation of the Sap in the Nitella flexilis, a Water-plant, was shown microscopically by Mr. C. Varley.

In the Ante-room was exhibited: —

A Sectional Model of Condensing Engine by Messrs. Watkins and Hill.

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* See "Wonders of Geology," Sixth Edition, p. 893.

† Lyell's "Manual of Geology," Fourth Edition, p. x.

reality of this domination; thus a biologized subject may be brought to feel the apartment so intensely hot, that a perspiration breaks out upon his skin; or he may be so persuaded of its coldness, that he forthwith begins to shiver; and sleep may often be induced, by assuring him that in a few minutes he will be obliged to give way to it. In a case witnessed by the Lecturer, a lady to whom chloroform had been twice administered (so that she was aware of the the mode of its action) was made to believe that she was again inhaling it; she soon passed into the usual insensibility, and remained perfectly unconscious for a few minutes, after which she came to herself in the manner she would have done if she had really been under the influence of chloroform.

The same general statement applies to what has been designated as 'control over the memory.' The subject is assured that he cannot remember the most familiar thing, his own name for example; and he is prevented from doing so, not by the will of the operator, but by the conviction of the impossibility of the mental act, which engrosses his own mind, and by the want of that voluntary control over the direction of his thoughts, which alone can enable him to *recal* the desiderated impression. And the abolition of the sense of personal identity,— Mr. A. believing himself to be Mrs. B., or Mrs. C. believing herself to be Mr. D., and acting in conformity with that belief,—is induced in the same mode; the assurance being continually repeated, until it has taken full possession of the mind of the 'subject,' who cannot so direct his thoughts as to bring his familiar experience to antagonize and dispel the illusive idea thus forced upon him.

Now almost every one of these peculiar phenomena has its parallel in states of mind whose existence is universally admitted. Thus the complete subjection of the muscular power to the 'dominant idea' is precisely what is experienced in *nightmare;* in which we are prevented from moving so much as a finger, notwithstanding a strong desire to do so, by the conviction that the least movement is impossible. The misinterpretation of sensory impressions is continually seen in persons who are subject to *absence of mind,* who make the most absurd mistakes as to what they see or hear, taste or feel, in consequence of the pre-occupation of the mind by some train of thought, which renders them unable rightly to appreciate the objects around them. In such persons, too, the memory of the most familiar things,— as the absent man's own name, for example, or that of his most intimate friend,— is often in abeyance for a time; and it requires but a more complete obliteration of the consciousness of the past, through the entire possession of the mind by the intense consciousness of the present, to destroy the sense of personal identity. This, indeed, we often do in effect lose in ordinary *dreaming* and *reverie.* The essential characteristic of both these states, as of the 'biological' condition, is the suspension of voluntary control over the current of thought, so that the ideas follow one another *suggestively;*

and, however strange or incongruous their combinations or sequences may appear, we are never surprised at them, because we have lost the power of referring to our ordinary experience. It is well known that the course of ordinary dreams is often determined by impressions received through the organs of sense, although the individual may not be conscious of them *as such;* and those who are prone to reverie are well aware that the direction of their thoughts depends in many instances, not merely upon the previously existing associations between their ideas, but upon the excitement of new ideas by external impressions.

There is one phenomenon of the 'biological' state, which has been considered pre-eminently to indicate the power of the operator's will over his subject; namely, the induction of sleep, and its spontaneous determination at a given time previously ordained, or by the sound of the operator's voice, and that only. It is well known that the *expectation* of sleep is one of the most powerful means of inducing it, especially when combined with the withdrawal of the mind from everything else which could keep its attention awake; both these conditions are united in an eminent degree in the state of the biologized subject, whose mind has been possessed with the conviction that sleep is about to supervene, and is closed to every source of distraction. Nor need the waking at a given time, or upon a given sound (and upon that only), be accounted at all more strange; for it is a matter of familiar experience, that this is often determined, in the case of an ordinary sleeper, by the impression under which he passes into unconsciousness; the fixed intention to awake at a certain hour being productive of the exact consequence; and the habit of attention to a particular sound, as that of a clock, bell, voice, &c., causing the sleeper to awake upon the slightest provocation from it, although his slumbers are not broken by noises of far greater intensity.

Thus, then, however strange the phenomena of the 'biological' state may at first sight appear, there is not one of them, which, when closely scrutinized, is not found to be essentially conformable to facts whose genuineness every physiologist and psychologist is ready to admit. And the chief marvel is, that a state in which these phenomena are so easily and constantly producible, should be capable of being induced by so simple a process as that of gazing for a time at a small fixed object at arm's length from the eyes.*

It is not, however, in any large proportion of individuals, that this state can be induced; probably not more than one in twenty, or at most one in twelve. Males appear equally susceptible of it with

* The "Electro-Biologists," as they term themselves, at first maintained that a wonderful virtue resided in the little disk of copper with a zinc centre, to which they directed the gaze of their 'subjects.' It is now universally admitted, however, that *any* object which serves as a *point d'appui* for the fixed gaze, is equally efficacious.

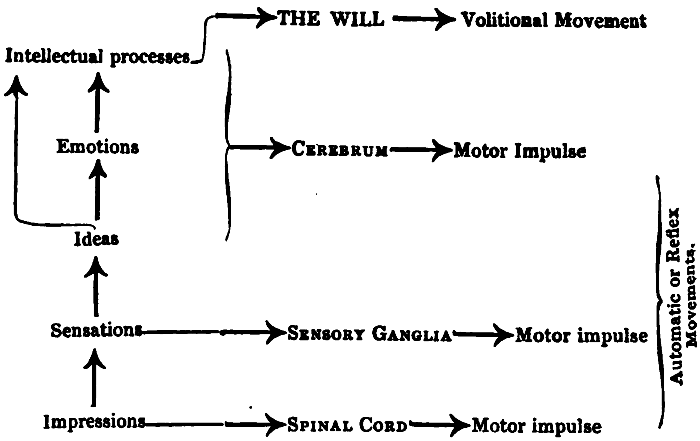
females; so that it cannot be fairly set down as a variety of 'hysterical' disorder. Generally speaking, those who have most of the power of voluntary abstraction are most easily affected in this mode; more especially if, at the same time, they are of an excitable or imaginative temperament.

It now remains to enquire, whether any such Physiological account can be given of this state, as shall enable us to refer it to any of the admitted laws of action of the Nervous system. This, the Lecturer stated, was the point which he was most desirous of elucidating; and in order to prepare his auditors for the reception of his views, he gave a brief explanation of those phenomena of 'reflex' action (now universally recognized by Physiologists), in which impressions made upon the nervous system are followed by respondent automatic movements. Such movements have hitherto been distinguished into the *excito-motor*, which are performed, without the exciting impression being necessarily felt, through the instrumentality of the Spinal Cord and the nerves connected with it; and the *sensori-motor*, in which sensation necessarily participates, the respondent motions not being executed unless the impressions are felt, and their instrument being the chain of Sensory Ganglia (collectively constituting the 'sensorium') which lies between the Spinal Cord and the Cerebrum, and is intimately connected with both. The automatic movements of breathing and swallowing, which continue during a state of profound insensibility, are examples of the former group; whilst the start upon a loud sound, the closure of the lids to a flash of light, or the sneezing induced by dazzling of the eyes, as well as by irritation in the nasal passages, are instances of the latter. The whole class of purely *emotional* movements may be likened to these; for in so far as they are involuntary, and depend upon the excitation of certain states of mind by external impressions, they must be considered as 'reflex' in the general sense of that term.

Now the usual *modus operandi* of sensations is to call forth *ideas* in the mind; and these ideas, associated or not with emotional states, become the subjects of intellectual processes, which result at last in a determination of the Will. The movements which we term *voluntary* or *volitional* differ from the emotional and automatic, in being guided by a distinct conception of the object to be attained, and by a rational choice of the means employed. And so long as the Voluntary power asserts its due predominance, so long can it keep in check all tendency to any other kind of action, save such as ministers directly to the bodily wants, as the automatic movements of breathing and swallowing.

The *Cerebrum* is universally admitted to be the portion of the nervous system, which is instrumentally concerned in the formation of ideas, the excitement of the emotions, and the operations of the intellect; and there seems no reason why it should be exempted from the law of 'reflex action' which applies to every other part of

the nervous system.* And as we have seen that the *emotions* may act directly upon the muscular system through the motor nerves, there is no *a priori* difficulty in believing that *Ideas* may become the sources of muscular movement, independently either of volitions or of emotions.—The relations of these different modes of action of the nervous system, and the place which this *ideo-motor* form of 'reflex' operation will hold in regard to the rest, will be made more apparent by the following tabular arrangement.




Now if that ordinary *upward* course of external impressions,—whereby they successively produce sensations, ideas, emotions, and intellectual processes, the will giving the final decision upon the action to which they prompt,—be anywhere interrupted, the impression will then exert its power in a *transverse* direction, and a 'reflex' action will be the result. This is well seen in cases of injury to the Spinal Cord, which disconnects its lower portion from the sensorium without destroying its own power; for impressions made upon the lower extremities then excite violent reflex actions, to which there would have been no tendency if the current of nervous force could have passed upwards to the Cerebrum. So, if sensations be prevented by the state of the Cerebrum from calling forth ideas through its instrumentality, they may react upon the motor apparatus in a manner which they would never do in its state of complete functional activity. This the Lecturer maintained to be the true account of the mode, in which the locomotive movements are maintained and guided in states of profound abstraction, when the whole attention of the individual is so completely concentrated upon his

* To Dr. Laycock is due the credit of first extending the doctrine of reflex action to the Brain.

own train of thought, that he does not *perceive* the objects around them, although his movements are obviously guided by the impressions which they make upon his sensorium. And he adverted to a very remarkable case, in which the functional activity of the Cerebrum seemed to have been almost entirely suspended for nearly a twelvemonth, and all the actions of the individual presented the automatic characters of consensual and reflex movements.

On the same grounds, it seems reasonable to suppose that when *ideas* do not go on to be developed into emotions, or to excite intellectual operations, they, too, may act (so to speak) in the transverse direction, and may produce respondent movements, through the instrumentality of the Cerebrum; and this will of course be most likely to happen, when the power of the Will is in abeyance, as has been shown to be the case in regard to the direction of the thoughts, in the states of Electro-biology, Somnambulism, and all forms of Dreaming and Reverie. Here the movements express the ideas that may possess the mind at the time; with these ideas, emotional states may be mixed up, and even intellectual operations may be (as it were) automatically performed under their suggestive influence. But so long as these processes are carried on without the control and direction of the Will, and the course of thought is entirely determined by suggestions from without, (the effects of which, however, are diversified by the mental constitution and habits of thought of the individual) such movements are as truly automatic, as are those more directly prompted by sensations and impressions, although originating in a more truly *psychical* source. But the automatic nature of the purely emotional actions can scarcely be denied; and as it is in those individuals in whom the intellectual powers are the least exercised, and the controlling power of the Will is the weakest, that the Emotions exert the strongest influence on the bodily frame, so may we expect Ideas to act most powerfully when the dominance of the Will is for the time completely suspended.

Thus the *ideo-motor* principle of action finds its appropriate place in the physiological scale, which would, indeed, be incomplete without it. And, when it is once recognized, it may be applied to the explanation of numerous phenomena which have been a source of perplexity to many who have been convinced of their genuineness, and who could not see any mode of reconciling them with the known laws of nervous action. The phenomena in question are those which have been recently set down to the action of an "Od-force," such, for example, as the movements of the 'divining-rod,' and the vibration of bodies suspended from the finger; both which have been clearly proved to depend on the state of *expectant attention* on the part of the performer, his Will being temporarily withdrawn from control over his muscles by the state of abstraction to which his mind is given up, and the *anticipation* of a given result being the stimulus which directly and involuntarily prompts the muscular movements that produce it.

[W. B. C.]

In the Library were exhibited : —

Testimonial (in silver) to Dr. Conolly, by Messrs. Hunt and Roskell.

Geological Section of Well sunk at the Bank of England, Jan. 1852. [Exhibited by Thomson Hankey, jun. Esq., Governor of the Bank.]

Two Cases of Indian Butterflies — Lion's Cubs — an Elephant's Tusk, — from the United Service Institution.

Sundhya, or Daily Prayers of the Brahmins, illustrated by Mrs. S. C. Belnois — Japanese Sandals, Reaping-hook, Pen and ink case, Telescope-tube, Playing-Cards, Tea-kettle, and Tobacco-pouch — Chinese and Japanese Dictionary — Tablet of Earth from tomb of Ali, used at their devotions by the Mahometans of the Shiah Sect, — from the Royal Asiatic Society.

Femur of the Plesiosaurus, from the Kimmeridge Clay, Bucks — Ammonites heterophyllus — Vertebræ of Ichthyosaurus from Lias, Lyme, Dorset — Fossil wood, &c. [Exhibited by Mr. Tennant.]

Varley's Microscope with Lever stage movement, shewing Infusoria, Rotatoria, Monoculi or Water fleas, in which the *heart* was seen *beating*, and all their internal structure, their eggs, their young, and the muscles which move the eyes.

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## WEEKLY EVENING MEETING,

Friday, March 19.

WM. POLE, Esq., M.A., F.R.S., Treasurer and Vice President, in the Chair.

J. J. BIGSBY, M.D., F.G.S.,

Member of the American Philosophical Society (late British Secretary to the Canadian Boundary Commission),

### *On the Physical Geography, Geology, and Commercial Resources of Lake Superior.*

[THE following statements are partly derived from the able reports and charts of Messrs. Bayfield, Logan, Foster, Owen, and others in the service of the governments of Great Britain and the United States, Dr. Bigsby's own researches on the northern shores of the Lake, for 440 miles, having supplied the remainder.]

LAKE SUPERIOR is included between W. Longitude 84° 18′ and 92° 19′ — and N. Latitude 46° 29′ — 49° 1′. It is to the east of, and near to, the swell of high land which, stretching from the Rocky Mountains to Lake Superior, in wide undulating plains,

divides the waters of the Mexican gulf from those of Hudson's Bay; — and then, bifurcating, one fork proceeds on the north side of Lake Superior eastwards towards Labrador, in groups of broken hills, while the other fork passes south-east as a rough and high country into the lowlands of the United States. It therefore occupies an oblong crescent-shaped hollow, with a general direction rather to the north of east. It has literally thousands of lakes on its north, and hundreds on its immediate south. It is 1750 miles round, 420 miles long, and 163 in extreme breadth. It is 597 feet above the Atlantic. Its greatest known depth is 792 feet. Soundings of 300, 400, 600 feet are common; but extensive shallows and flats prevail in parts.

The hydrographic basin of Lake Superior is singularly small, particularly on the south shore, where the tributaries of the River Mississipi and Lake Michigan often approach within 5 and 10 miles of the lake. It seems to be its own fountain head.

The water is clear, greenish, extremely pure, pleasant to the taste, and soft from the nearly total absence of limestone from these regions. An imperial pint only contains $\frac{1}{5000}$ part of a grain of mineral matters — carbonates of lime and magnesia, sulphate of lime, peroxide of iron, and the oxide of manganese.

The average annual temperature of the water is 40° F.; being about the same as that of the ocean at certain great depths. In June, the lake is often covered with ice; and in the middle of July, the surface-water freezes in the morning — with patches of snow in the clefts of the rocks. At this period of the year, or a few days later, the smaller lakes on the north are steadily at 72° and 74°. F.

Lake Superior is not undergoing secular drainage. It is lowest in April, and highest by a few feet, in September. The great annual variations of rain of these countries produce corresponding changes of level. There are no tides, and no cycle of years for lake-levels.

Barometric changes produce curious local oscillations of level. Thus the furious rapids, called the Falls of St. Mary, on the river of discharge so named, are sometimes left dry. Messrs. Foster and Whitney have seen the oscillation come from the centre of the lake in a wave 20 feet high — curling over like an immense surge, crested with foam, and breaking on the shore, diminishing as it approached it. On this occasion (Aug. 1845) it was the harbinger of a violent storm.*

The amount of water leaving the lake is small; for its outlet is often shallow, and the current weak.

* A violent gale of wind, concurring with a local rise of level, will sometimes throw large stones or logs of wood 150-200 yards inland, and 30-40 feet above the usual water margin—as in three instances seen by Prof. Agassiz (L. Superior, pp. 95 and 106), and by Dr. Bigsby. (Journ. Roy. Instn. xviii. 15.)

The *Climate* is more arctic than temperate, although the lake is but little to the north of Milan. It is much colder than Sikla in Russian America, 10° further north; because the latter is screened from polar winds. Winter begins in the middle of October by a succession of gales and snow storms; and from November till May the ground is covered with close packed, granular snow: but the earth is not frozen deep, so that, in spring, before all the snow is gone, the forest is in leaf. The annual range of the thermometer is 125° F. the mean 42° 14′ F., the lower extreme — 31°, the higher 94°; all these observations having been made by good observers, with excellent instruments. August is the hottest month.

On a mean of 12 years, the Winds blow about equally from all quarters; from the N.W. the most frequently — from the South the least frequently.

(The principal promontories, bays, rivers and heights of Lake Superior were pointed out on the map.)

The scenery of Lake Superior is striking; — its features are large and open (of which an example was shewn in a Sketch on the East Coast). The eye ranges over high lands and shoreless waters. The scanty and dwarfed woods of the north coast, the rocks, isles, and rivers full of cascades, have an impress of their own — not warm, soft, and umbrageous like those of Lake Erie; but rugged, bare and chill — arctic. The scene is oceanic, — the waves are large and high. Some of the plants, the Lathyrus Maritimus and the Polygonum Maritimum, for instance, on the beaches, and many of the insects disporting about, are those of the distant Atlantic.

In winter, Lake Superior might be called the "Dead Sea;" every living thing is gone, save the shivering inhabitants of some few white settlements. The Indian and the wild animals have retreated to the warm woods far away; and the sun looks down, from a bright blue sky, on the leaden waters, now narrowed by huge fields of ice — a small dark speck on an almost illimitable expanse of snow.

On the south shore, there are in the extreme east, high terraces and treeless plains of blown sand for many miles inland and along shore, succeeded by the high sandstone precipices, called the Pictured Rocks, battered into fanciful shapes by the violence of the waves. Then comes a low rocky coast for 200 miles or more, backed by dense forests, often mountainous, as at the Huron, Bohemian, and Porcupine mountains. The scene is dark with the verdure of northern evergreens, and is here and there diversified with small clearings, and the smoke of distant mines ascending among the uplands. The bays are often deep—full of little iron-stained streams; and the promontories stretch for miles into the lake.

The Eastern and Northern shores are different — more naked, steeper, ever abounding in dome-shaped hills, or in ridges, rising by steps, scantily covered with trees either stunted or scorched with

fire. (Large sketches were exhibited representing the lofty basaltic country about Fort William, and the softer hill-scenery of Black Bay.)

With the exception of the Fur trading stations, there are no white settlements on the north shore: — and this from its general barrenness. At the Peek River, soil was imported in bags with which to raise a few potatoes.

The *Fauna* and *Flora* of Lake Superior are semi-arctic — or subalpine. Professor Agassiz has treated of both in his late valuable publication on this lake. He found twenty-three new species of fish, and states that Lake Superior constitutes a special ichthyological district. The reason of this evidently lies in the coldness and extreme purity of the water, its slow departure towards the ocean, and the absence of weedy bays, and of lime rocks.

It would seem that some portion of its animal life are waifs and strays from grand geological periods long passed away — as we see in its herrings, minnows, and the new genus Percopsis. Connected with this subject, Prof. Agassiz conjectures that much of North America was dry land when the rest of the world was under water; and that thus its physical condition was less altered than elsewhere. Dr. Bigsby was inclined to believe this, for had Canada been as long under water as other large tracts, we should probably have had in some part of its vast extent, a member or two, at least, of the mesozoic rocks; but there is no such thing — not a single relic of lias, oolite, or chalk, in the extraordinary heaps of débris which overspread these countries.

*Geology.** The rocks of Lake Superior have been arranged under three principal heads, as follows: —

1. The *Metamorphic.* — Greenstone, chloritic, talcose, clay and greenstone slates, gneiss, quartzite, jasper, rock and saccharoid limestone.
2. The *Aqueous.* — Calciferous sandstone, Cambrian sandstone and conglomerates.
3. The *Igneous.* — Granite, Sienite, Trap, in various states.

The place and extent of these rocks having been pointed out on a map, Dr. Bigsby stated that the geological system of Lake Superior is a consistent and closely connected whole, forming a beautiful and easily read example of geological action in moulding the surface of our globe.

The lake may best be presented at once to the mind as a trough or basin of Cambrian (or Silurian) sandstone, surrounded, and framed as it were, by two orders of rocks, in the form of irregular and imperfect zones; the inner consisting of trap, with its conglomerates; and the outer, of metamorphic, flanking igneous rocks.

* This branch of the subject was illustrated by numerous coloured Diagrams, and specimens of native copper, and of the rocks of the lake.

1. The ***Metamorphic*** rocks, with the exception of Quartzite and Jasper, are the oldest in the lake, and support great sheets of the abovementioned sandstone unconformably; all these rocks being upheaved and altered by the intrusion of igneous rocks in instances innumerable. This group of rocks are entirely destitute of the traces of animal life.

The country they occupy on the south shore, with a general NNW. dip, may be best described as a rough table land of the various slates, out of which short hills of granite, gneiss, trap, &c. emerge in great numbers, with an almost constant east and west direction.

On the east and north shores the metamorphic rocks have a W. and WSW. strike, when visible. The slates of the north side of Michipicoton Bay run WNW., NW., and N.

The Jasper and Quartzite are merely altered sandstone and therefore younger than the other rocks of this group.

2. The *Aqueous* Rocks. The youngest of these is Calciferous Sandstone. It exists as a broad band on the south-east shore, resting on the sandstone soon to be noticed. It is highly magnesian and siliceous in parts. A patch of it in Grand Island contains shells. (Logan.)

The Cambrian Sandstone seems to be the floor or basement of nearly all the lake, for the following reasons :—

1. Wherever it occurs, whether in immense sheets on the east and south shore, or in smaller areas on the north coast, it invariably dips towards the centre of the lake.
2. It can be recognised, paving the lake for some miles from the main in many places.
3. The soundings of Captain Bayfield exhibit, for large spaces, the uniformity of level to be expected from the presence of horizontal strata.
4. Because it constitutes Caribou Island, 40 miles from the nearest main land.

This sandstone is very ancient; and is supposed by Mr. Logan to be Cambrian on the north shore and lower Silurian on the south — a supposition, the latter clause of which, though extremely probable, is not yet established.

It has no fossils; but its ripple marks, impressions of rain-drops, and sun-cracks, are plentiful and perfect.

It is more commonly red, and is composed of the débris of granitoid rocks, in nearly horizontal strata, except near intrusive rocks, when it rises to an high angle, hardens, and even passes into true Jasper, porphyry, gneiss or quartzite. There is reason to think that this sandstone is interleaved with trap. (A Landscape was exhibited of the Sand stone Rocks, south shore.)

The Conglomerate is of the same age with much of the sandstone; and is almost invariably placed between it and the trap.

The conglomerates of Keweenaw and Isle Royale consist of rounded bowlders of trap, with a few Jaspers, cemented by red iron sand; but those of Memince and Nipigon contain also granites, quartzites and sandstones; thus indicating a difference of age.

3. *Igneous* Rocks. Granite every where forms the nucleus of an anticlinal axis, in two parallel lines running E. and W.on the south-east side of the lake, flanked by metamorphic and sedimentary rocks. Both it and Sienite are plentiful.

*Trap Rocks*. The ancient lavas of the lake are in very large quantities, and are well displayed. They are the great depositories of copper. For convenience sake, they may be divided into three principal forms.

1st. The highly crystalline mountain masses,—sometimes anticlinal and sienitic.
2nd. The bedded trap, at various angles of inclination.
3rd. Dykes intersecting igneous and metamorphic rocks.

They are all portions of one long series of volcanic operations.

Trap creates the great headland of Keweenaw, with its lines of stair-like cliffs and hills. (It was shewn in a large diagram and described as typical of the trap of the whole lake.) The trap of Keweenaw is met with in three contiguous and parallel belts, going WSW., and separated by bands of conglomerate, sometimes very thin, often numerous, and prolonged sometimes for 40 or 50 miles. These three belts have been named the outer, northern, and southern; the last being highly crystalline, or sienitic, and abounding in chlorite. It is an anticlinal to the rocks on both sides. The other two belts are bedded traps, and with their interleaved conglomerates dip northerly. They all coalesce at Portage Lake and after proceeding to Montreal River, 130 miles in the whole, soon after disappear under horizontal sandstone westwards.

The north belt is the most metalliferous; and contains the celebrated Cliff and other rich mines. In the Keweenaw district it is the cross vein which yields the native copper—either in sheets and blocks or mixed in with the usual crystallizations, such as datholite, prehnite, stilbite, quartz, &c.

On the Ontonagon River the metalliferous veins run with the strike. The copper is pure, and has interspersed through its substance, scales of pure silver; but without chemical union.

The copper is confined to the trap, as an universal rule.

The North shore of Lake Superior is eminently trappose; and especially about Fort William, where a region at least 120 miles long consists of basalt, amygdaloid, porphyries, jasper, conglomerate, and sandstone in the same mutual relations as on the south shore.

The trap dykes, traversing granites and other crystalline rocks indifferently are a singular feature on the north shore and abound chiefly from Written Rocks to the bottom of Michipicoton Bay. By their dark and undeviating course through the grey, red, or green rocks of the rugged coast, they strike the eye of the most incurious — if only as ruined staircases, crossing bays and headlands and climbing hills for miles. Their size, number, and direction are irregular. They may be solitary, or twenty in company — sometimes all parallel and close together. They often run with the general trend of the coast.*

Mr. Logan divides them into three varieties, according as they are homogeneous, sienitic or porphyritic.

Professor Agassiz distributes the dykes of the whole lake into six systems — each with its own mineral character and direction — its own epoch of upheaval; and each he announces to have been an important agent in giving shape and direction to the district in which it occurs. He truly says that the general outline of the lake is the combined effect of many minor geological events taking place at different periods. With some truth in it, this theory does not seem to take into sufficient account the pre-existing metamorphic and granitic rocks, and it overlooks the variety observed in the directions of the dykes in the same neighbourhood.

Dr. B. stated that if he might be allowed to hazard an opinion, it would be, that this curious assemblage of dykes — abounding as much in the S. as on the N. coast—pervading all the crystalline rocks indiscriminately, had ascended independently from the unseen, distant, mass of trap beneath. They appear in many ways peculiar, and have no visible connexion with the traps he had been describing.

Before the emergence of either traps or granites, Lake Superior received its *great* outlines from the metamorphic rocks,—thrown into their present position by still earlier upward movements: for on the eastern half of both shores of the lake they strike E. and W. with little variation, while on the western half, these far extending rock-masses strike WSW. and SW. — giving thus, to the lake, a general eastward direction, with a gentle curve to the north, as stated before. This done, Cambrian Sandstone slowly took possession of the trough of the lake — just as we see a certain shell marl is doing now. The anticlinal Granites, which appeared afterwards, only concurred in the same effects; — shaping and elevating the adjacent lands.

In after-geological times important modifications arose in the form of the lake. Promontories were pushed out, and islands raised up by successive outbursts and overflows of trap from separate fissures of great length — those for example of Keweenaw, Thunder Mountain, and Isle Royale — all intercalated with conglomerates,

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* Vide Quart. Journal of Roy. Inst. Vol. XVIII. p. 244. Bigsby on Lake Superior.

formed in agitated seas between eruptions; — at different and most probably *distant* times, judging from the fact that some of the conglomerates are altogether trappose, while others abound in granite and other bowlders.

We thus obtain the *general* order of all these events, and little more; but the knowledge is worth having. From the position of the up-lifted mural cliffs, we see that the upheaving impulse came from the south-east.

*Drift*. The groovings and striæ are almost always northerly here. New proofs are daily accumulating to shew still more decisively the northerly origin of the foreign drift of Lake Superior. One of these is the fact that the limestone bowlders on the north shore are upper Silurian,* and derived from the large calcareous basins some hundreds of miles north of Lake Superior: from whence Dr. B. had brought characteristic fossils. Another is found in the occurrence of bowlders of iron ore, in heaps, on the north side of certain cliffs, but which are absent on the south side — the original site of the ore, being to the north of the cliffs, and near Lake Superior.

A Sketch was exhibited of a Wisconsin prairie, dotted with northern blocks dropped from icebergs.—From Dr. D. Owen.

*Commercial Resources.* — Agriculture will only be carried on in parts of the south shore. Large quantities of white fish, and of furs are annually exported.

The chief staple of Lake Superior is native Copper. For ages before the appearance of Europeans in America, this metal was supplied from hence to the Indian nations far and near. The tumuli of the Mississipi, &c. contain the identical copper of this lake. Traces of ancient mining in Keweenaw, Ontonagon, and Isle Royale are abundant, in the form of deep pits (a ladder in one), rubbish, stone mauls, hammers, wedges, and chisels of hardened copper. In a native excavation, near the river Ontonagon, with trees five hundred years old growing over it, lately lay a mass of pure copper 81 tons in weight, partly fused and resting on skids of black oak.

Modern explorers have hitherto only found two centres of metallic riches on the south coast, — that of Keweenaw and of Ontonagon. In the first are the valuable mines of the Cliff, North American, North-western and other companies. In the Ontonagon centre is the Minnesota and fifteen other mines.

At the Cliff mine three large steam engines are employed (1852); with 250 men; — and at the North American mine, two engines, with 160 men. Most of the other mines, forty in number, are assisted by steam power. Three thousand miners are in work altogether, and the general population is fast increasing. Native copper is the principal object. Silver is always present, and occasionally in masses of considerable size. According to authentic

* Containing Pentamerus, Spirifer, Leptæna (alternata) atrypa, various corals, minute trilobites, orthoceræ, and some cytherinæ.

accounts, dated February, 1852, many new mines have been opened lately; and all are worked more systematically than heretofore, — generally by contract.

There are now in the Cliff mine masses of pure copper within view estimated to weigh 700 tons in the whole; and on the lands of the Minnesota Company, one block weighing 250 tons. The copper shipped in 1851 was about 1600 tons, valued at £130,000. This copper is stated to be of great excellence in the manufacture of wire, ordnance, and ship-sheathing.

The large beds of specular and magnetic iron ore, on the south-east side of the lake, are as yet only worked on a small scale.

At this moment the business of mining has ceased on the Canadian side of the Lake. There is little doubt, however, but that profitable deposits will, sooner or later, be discovered here.

[J. J. B.]

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In the Library were exhibited: —

Falls in the Black River, Lake Superior, and other Views in Canada, by Dr. J. J. Bigsby, M.R.I.

Roman Glass Vase, a small Bottle, and a Lamp found in the church-yard of St. Stephen's (near St. Alban's) about $6\frac{1}{2}$ ft. deep, a quarter of a mile from the Roman Verulam. The Vase contained pieces of bone and was much broken; it was repaired by Mr. Doubleday of the British Museum as far as possible. Not any part of the rim was discovered. [Exhibited by S. R. Solly, Esq., M.R.I.] [See a Pamphlet by M. H. Bloxam, Esq., on the Roman Sepulchral Remains found near St. Alban's, 8vo. 1849, — presented to the R. I. Library by Mr. S. R. Solly.]

Specimens of British Glass and Porcelain. [Exhibited by Mr. Apsley Pellatt.]

Models of Marine Engines: — Double Cylinder Engine and Vibrating Engine — and Engine of the "Great Western." [Exhibited by Messrs. Maudslays and Field.]

Rough Models of Nasmyth's Steam-hammer and of Maudslay's Vibrating Cylinder, from the Royal Institution Laboratory.

Diagrams of Nasmyth's Steam Pile-driver. [Presented by Mr. Nasmyth.]

Model of the Disk-Engine by Mr. R. Addams.

A Group of Humming-birds, from S. America, and a Group of Tanagers from neighbourhood of Rio Janeiro, Mounted by Messrs. Leadbeaters.

Mr. Varley exhibited a Vial Microscope in which were shewn the circulation of the sap of a Plant, and a group of Trumpet animalcules. The rapid motion of their cilia by which they catch their prey was perceived.

[FOR THE USE OF MEMBERS.]

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# Royal Institution of Great Britain

1852.

## WEEKLY EVENING MEETING,

Friday, March 26.

SIR JOHN P. BOILEAU, Bart., F.R.S., Vice-President, in the Chair.

PROFESSOR E. COWPER,

*On the Principles of the Construction and Security of Locks.*

PROFESSOR COWPER, after pointing out the peculiarities of construction in the more celebrated Locks of ancient and modern times, explained the mode by which Mr. Hobbs had succeeded in picking Bramah's, and other locks, and suggested additional means of security against such a procedure. His remarks were elucidated by numerous large models and diagrams.

Long continued illness has unfortunately prevented Professor Cowper from supplying an abstract of his discourse.

In the Library were Exhibited: —

Wooden Lock and Key made by the negroes of Jamaica, and another of a different form — Lock of wicket of the Castle of Pownghur — Key found in the thatch of an old house, St. Andrew's. — Profile of General Wolfe sketched in pencil by Harvey Smith, one of his Aide-de-Camps, a short time before his death at Quebec, — from the United Service Institution.

Wire Models to illustrate the Cleavage of the Diamond, &c. — and Large Pieces of Topaz Rock and Crystal of Beryl. [Exhibited by Mr. Tennant.]

Portrait on copper of Maurice of Nassau, probably by Mirevelt. [Exhibited by John Hicks, Esq. M.R.I.]

Bust of Thomas Carlyle, Esq. by H. Weigall, Esq.

Specimens of Printing in Colours by Blocks, by Messrs. C. B. and G. Leighton.

Design of Galloway's Tubular Boiler as adapted to Steam-boat purposes, by Mr. R. Armstrong.

A Set of Talbotype Apparatus; the Camera with improved Sliding Front — Talbotype, Negative and Positive, and various Portraits, by Mr. Henneman.

Boxes, and other Articles manufactured from Muslin and Cotton *Maché*, by Mr. G. Hart.

Paintings on China. [Exhibited by W. T. Copeland, Esq.]

## WEEKLY EVENING MEETING,

Friday, April 2.

SIR CHARLES FELLOWS, in the Chair.

SIR CHARLES LYELL,

*On the Blackheath Pebble-bed, and on Certain Phænomena in the Geology of the Neighbourhood of London.*

THERE are two kinds of flint-gravel used for making roads in the neighbourhood of London, both of them in certain places superficial, but which are of extremely different ages. The yellow gravel of Hyde Park and Kensington so often found covering the "London Clay" may be taken as an example of one kind; that of Blackheath, of the other. The first of these is, comparatively speaking, of very modern date, and consists of slightly rolled, and, for the most part, angular fragments, in which portions of the white opaque coating of the original chalk flint remains unremoved. The more ancient gravel consists of black and well-rounded pebbles, egg-shaped or spherical, of various sizes, exhibiting no vestige of the white coating of the original flints, yet showing by the fossil sponges and shells contained in them that they are derived from the Chalk. In the pits of Blackheath and the neighbourhood, where this old shingle attains at some points a thickness of 50 feet, small pieces of white chalk sometimes occur, though very rarely intermixed with the pebbles. If we meet with thoroughly rounded flints in the more modern, or angular gravel, it is because the latter has been in part derived from the denudation of the older bed.

The researches of the Rev. H. M. De la Condamine have shown that the sand and pebble-beds of Blackheath and Greenwich Park, inclose in some of their numerous layers, freshwater shells of extinct species, such as Cyrena cuneiformis, &c. agreeing with fossils which characterize the Lower Eocene beds at Woolwich. At Lewisham the pebble-bed passes under the London Clay, and at Shooter's Hill this clay overlies it in great thickness.

At New Charlton, in the suburbs of Woolwich, Mr. De la Condamine discovered a few years ago a layer of sand in the midst of the pebble-bed, where numerous individuals of the Cyrena tellinella were seen standing endwise, with both their valves united, the posterior extremity of each shell being uppermost, as would happen if the mollusks had died in their natural position. Sir Charles Lyell described a bank of sandy mud in the delta of the Alabama river at Mobile, on the borders of the Gulf of Mexico, where, in 1846, he had dug out, at low tide, specimens of a living species of Cyrena, and of a Gnathodon, which were similarly placed, with their shells erect, a position which enables the animal to protrude its siphons

upwards, and draw in water to lubricate its gills, and reject it it has served the purposes of respiration. The water at Mol usually fresh, but sometimes brackish. Sir Charles examined la the Woolwich beds with Mr. Morris, and they verified Mr. De Condamine's observations, observing there several dozen specimens of the Cyrena tellinella in an erect position. From this circumstance the Lecturer infers, that a body of fresh or river water had been maintained permanently on that spot during the Eocene period, and the presence of rolled oysters in the associated pebbly layers, with other marine shells, mixed with species of Melanopsis, Melania, Cerithium and Neritina demonstrate that the sea occasionally invaded the same area. To an overflow of the pebbly sand in which the Cyrenæ lived by salt water, may probably be attributed the poisoning of the mollusks which left their shells uninjured on the spot where they had lived.

The stratum called "the shell-bed," which contains at Greenwich, Woolwich, Upnor near Rochester, and other places, a great mass of fresh water, brackish-water and marine shells, especially oysters, is observed everywhere to underlie the great pebble-bed. Its mode of occurrence implies the entrance of one or more rivers into the Eocene sea in this region. Other rivers draining adjoining lands are indicated by a similar assemblage of fluvio-marine fossils near Guildford and at Newhaven in Sussex. The vicinity of land to the South and West of Woolwich is shown by the occurrence at New Cross, Camberwell, and Chelsea of Paludina and Unio in strata evidently a prolongation of the Woolwich beds, and by fossil leaves of dicotyledonous trees and layers of lignite in some of those localities. On the other hand at the junction of the "London Clay," and the subjacent "plastic clays and sands," when followed in an opposite or easterly direction towards Herne Bay and the Reculvers, all signs of the freshwater formation disappear, and the pebble-bed is reduced to a thin layer, often a foot or a few inches in thickness. The origin of this shingle may have been chiefly due to the action of waves on a sea-beach. Its accumulation in great force at certain points where freshwater shells abound, seems to imply the entrance of rivers into the sea, which brought down some flints, and arrested the progress of others travelling as beach pebbles along a coast line, in a certain direction determined by the prevailing currents and winds. The spreading of the pebble-bed over a wide area may be accounted for by supposing a gradual subsidence of land, and the continually shifting of the coast-lines upon which shingle accumulated. This same subsidence is required to explain the superposition of the London Clay, a deep-sea deposit to the Blackheath or Woolwich beds which are of shallow water or littoral origin. One of the rivers of the Lower Eocene period swept into the sea at Kyson near Woodbridge in Suffolk the bones of a monkey of the genus Macacus, of a marsupial quadruped allied to the opossum, of a Hyracotherium, and other mammalia, which have been determined by Professor Owen, and which throw light on the inhabitants of the land, at an era antecedent to the deposition of the London Clay.

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Sir C. Lyell then exhibited some sections, recently published by Mr. Prestwich,* illustrative of the geology of the environs of London, and gave a rapid sketch of the successive Eocene groups from the London Clay and overlying Bagshot series with its nummulites to the Barton and Hampshire freshwater formations with their fossil quadrupeds. He then alluded to the tertiary strata next in the ascending order which he had recently studied in Limburg, Belgium, which are not represented in England, and next to the Miocene faluns of Touraine and the Pliocene strata or crag of Suffolk, and lastly to the still more modern glacial period and the brick-earth of the valley of the Thames. The last mentioned formation contains the bones of extinct quadrupeds mingled with shells of recent species terrestrial and fluviatile.

The numerous and important changes in the fauna of the globe, attested by these successive assemblages of extinct species, belonging to different tertiary eras, attest the vast lapse of ages, which separate the time when the freshwater beds of Woolwich and Blackheath were formed from the human period. But revolutions of another and no less striking kind have taken place contemporaneously in the physical geography of the northern hemisphere, revolutions on so great a scale that the greater part of the present continents of Europe, Asia, Northern Africa and North America with which the geologist is best acquainted, have come into existence in the interval of time here alluded to. It may also be confidently affirmed that the colossal chain of the Alps is more modern than the tertiary shingle of Blackheath. There was deep sea at the period when the London Clay was forming, precisely in the area where the loftiest mountains of Europe now rise into the regions of perpetual snow. In proof of this the Lecturer referred to the works of several modern geologists, especially to those of Sir Roderick Murchison, and to a Lecture delivered by Sir Roderick in the Royal Institution to show that the nummulitic formation which belongs to the Eocene period, and not to the very oldest part of that period, attains an elevation in some portions of the Swiss Alps of 8,000 or even 10,000 feet, and enters into the structure and composition even of the central axis of the Alps having been subject to the same movements and partaking of the same foldings and contortions as the underlying cretaceous and oolitic strata.

Sir Charles Lyell next proceeded to show that a great series of volcanic eruptions had occurred in Europe since the older Eocene strata of the neighbourhood of London were deposited. Not only Vesuvius and Somma as well as Etna and the extinct volcanoes of Southern Sicily but the trachytic and basaltic eruptions of the extinct volcanoes of central France are more modern than the London Clay. The evidence consists not only of the superposition of igneous rocks several thousand feet thick, to lacustrine strata of the middle

* "Prestwich, Geological Enquiry respecting the Water-bearing strata around London, &c." Van Voorst, 1851.

and upper Eocene periods, but also to the absence in the pebble-beds constituting the base of the tertiary series of Auvergne, Cantal, and Velay of any pebbles of volcanic origin.

The Lecturer concluded by stating that the formation of every mountain chain and every elevation and depression of land bears witness to internal changes at various depths in the earth's crust. The alteration has consisted sometimes of the expansion, and sometimes of the contraction of rock, or of the semi-liquifaction or complete fusion of stony masses and their injection into rents of the fractured crust occasionally manifested by the escape of lava at the surface. Every permanent alteration therefore of level may be regarded as the outward sign of much greater internal revolutions taking place simultaneously far below. Even the precise nature of the changes in the texture of rocks produced by subterranean heat and other plutonic influences since the commencement of the Eocene period can be detected in a few spots especially in the central axis of the Alps where the disturbing agency had been intense. The table might be covered with specimens of gneiss, micaschist and quartz rock, once called primitive, and once supposed to be of a date anterior to the creation of living beings, which nevertheless were sedimentary strata of the Eocene period which assumed their crystalline form after the flints of Blackheath were rolled into shingle, and even after the shells of the London clay and the nummulites of the overlying Bagshot sands were in existence.

Yet however remote may be the antiquity of the Blackheath pebble-bed as demonstrated by the vast amount of subsequent change in physical geography, in the internal structure of the earth's crust and in the revolutions in organic life since experienced, its origin is probably as widely separated from the era of the Chalk as from our own times. For the fossils of the chalk differ as much from those of the oldest tertiary strata near London, as do the last from the organic beings of the present era. Nevertheless the white Chalk itself with its flints is considered by every geologist as the production of a modern era, when contrasted with the long series of antecedent rocks now known, each formed in succession when the globe was inhabited by peculiar assemblages of animals and plants long since extinct.

[C. L.]

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In the Library were exhibited: —

Fifty Pebbles from Blackheath and Woolwich, collected by the late Major Boys of Woolwich — Specimens of Gold Quartz, Sulphuret of Mercury from California, and Topaz with Mica, &c. [Exhibited by Mr. Tennant]

Bronze Cast of Napoleon, taken shortly before death — Judge Fraser's Lion-spear — Caffre Instruments of War. [Exhibited by Dr. W. V. Pettigrew, M.R.I. &c.]

Seaward's Patent Brine-valve and Saline Detectors — and specimen

of the Salt deposited on a boiler. [Exhibited by Messrs. Seaward and Capel.]

The "Crouching Venus" of the Vatican, in Alabaster, — Machine Sculpture, by Mr. Cheverton.

A piece of Micacious Iron from Penrice, near Adelaide, New South Wales. [Exhibited by Mr. S. Hall.]

Photographs of Paris, &c. by Capt. R. A. E. Scott, R.N. [Exhibited by Sir Charles Fellows, V. P. R. I.]

Bracelet, — Ruby surrounded by Diamonds. [Exhibited by Madame Ratte.]

Lord Faversham's Prize Ox (in silver). [Exhibited by Messrs. Hunt and Roskell.]

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## RESIGNATION OF PROFESSOR BRANDE.

*April 3rd,* 1852.

On the 16th of March Mr. Brande communicated to the Managers his desire to retire from the Chair of Chemistry which he had held since May, 1813. This day he gave his final lecture, at the conclusion of which he addressed his audience in the following words: —

"In this course I have endeavoured to show the intimate relations that subsist between abstract science and the useful arts — between the refinements of modern chemistry and the improved and extended condition of some of our leading manufactures; — and, having brought it to a conclusion, I must take my leave. I may truly say that I unwillingly resign my professorship; but the attacks of hoarseness to which I am subject have of late so much interfered with my duties here, and are so manifestly aggravated by any exertion of voice, as to render the measure one, if not of necessity, at least of prudence.

"In the year 1812, when Sir Humphry Davy retired from office, I was desired by the Managers of this Institution to prepare a probationary course of lectures, which I delivered at this table in 1813, and was immediately after elected to the vacant chair; so that I have been officially attached to the Royal Institution for a period of forty years. During the greater part of that time, namely, from 1815 to 1848, I also delivered a series of lectures and demonstrations on theoretical and practical chemistry in the Laboratory below. They were intended for all denominations of students, and were given thrice weekly, from October to May. They were the first lectures in London in which so extended a view of chemistry, and of its applications, including technical, mineralogical, geological, and medical chemistry, was attempted; and I look back upon them with much satisfaction, because I think I may fairly claim for them the merit of having completed the scheme, and added to the usefulness of this Institution; of having helped to diffuse that knowledge and

love of the science now so general; of having done so amongst all grades and classes of students; of having, therefore, fulfilled one of our principal objects.

"As to the lectures in this theatre, I must not pretend to conceal from you that I relinquish *them* with regret. The teaching of chemistry *here* has always been a delight to me; and to have successfully taught it for so extended a period, and to such an audience, has been, and indeed can be, the privilege of a very few; and believe me, I duly appreciate it, and that I look back with feelings, which I cannot represent in words, at the confidence which the successive Managers of this Institution have placed in me; and at the uninterrupted kindness and attention with which my imperfect endeavours to set forth the truths of chemical science in their varied relations, as evidences of the wisdom, power, and beneficence of the Creator on the one hand,—and, on the other, in their multifarious bearings upon the sister sciences and upon the useful arts, have been received.

"There are also other considerations which necessarily press themselves upon me at the present moment, arising out of a retrospect of the very large portion of my life which has been passed within these walls, and as an officer of this establishment. I rejoice in leaving it, in all respects, more prosperous than at any former period; its scientific fame more pre-eminent; its foundations more secure; its halls more frequented; its usefulness more acknowledged; and I cannot help discerning in this Institution one fertile source of that popularity of science, and extension of schools for scientific instruction, which so peculiarly distinguish the present age, and has more especially manifested itself in this mighty metropolis.

"Looking *personally* at the Royal Institution, I revere it, as my *alma mater*, where as a schoolboy I listened to the fruitful eloquence of Davy, and afterwards partook of his acquaintance and friendship; where I acquired the patronage of Sir Joseph Banks; where I was singled out by Wollaston as his successor in the secretaryship of the Royal Society; where I came into the frequent contact of the chiefs of science, and of literature and art; where Faraday became my pupil, colleague, and friend. These, I assure you, are only a very few of the proud and pleasing reminiscences which accompany me from this place; and they are unsullied and unalloyed; they have never been clouded, tainted, or embittered. I again, therefore, thank you for all your partiality and kindness; and in gratitude to Providence, in whose hands are all the issues of our lives, I respectfully beg you to accept my affectionate farewell."

The Secretary being then called to the Chair, it was moved by Sir Charles Clarke, Bart., seconded by John Pepys, Esq., and carried unanimously, that the thanks of the Meeting be returned to Professor Brande for the great benefits which the Institution had derived from the zeal, ability, and urbanity, with which he had discharged the duties of his office during the long period of thirty-nine years.

## GENERAL MONTHLY MEETING,

April 5, 1852.

WILLIAM POLE, Esq., M.A., F.R.S., Treasurer and Vice-President, in the Chair.

Octavius Brown, Esq.
Rev. James Brownbill.
Abel Jenkins, Esq.
Charles Lyall, Esq.
George Whitlock Nicholl, Esq.
Edward Owen Tudor, Esq.

were *admitted* Members of the Royal Institution.

The Lord Ashburton.
Hon. Augustus Calthorpe.
John Spofforth Dixon, Esq.
William Windham Horner, Esq.
Rev. Cyril Page.
Wyndham Portal, Esq.
Alexander Shaw, Esq.

were duly *elected* Members of the Royal Institution.

The following Report was read: —

RESIGNATION OF PROFESSOR BRANDE.

"*Royal Institution, April* 5, 1852.

"The Managers report: That at their Meeting held on the 16th ult. Professor Brande announced his intention to resign his Professorship of Chemistry in the Royal Institution on account of his health: Whereupon it was Resolved: That the Committee of Managers receive with great regret the communication from Mr. Brande that he feels compelled on account of his health to resign his Professorship of Chemistry, and in accepting his resignation, they wish unanimously to express to him their high sense of the ability, intelligence, and urbanity, with which, during thirty-nine years he has fulfilled the duties of his office; —

"That it was on that day also Resolved: That in further testimony of the high estimation entertained of Mr. Brande's eminent services, he be recommended to the Members of the Institution for Election as Honorary Professor of Chemistry; and that these Resolutions should be communicated to Mr. Brande.

"The Minutes containing these Resolutions having received the confirmation of the Managers at the following Meeting of the Committee held on this day, the Managers report them to the Members; and in so doing they invite the Members to confer on Professor Brande that high distinction which he will most appreciate, and which will be most expressive of their estimation of his services."

On the Motion of Professor Faraday, seconded by Sir John P. Boileau, Bart., and agreed to unanimously, —

W. T. Brande, Esq., F.R.S., L. & E., was put in nomination from the Chair as Honorary Professor of Chemistry in the Royal Institution (in conformity with Chap. XIX. Art. 2. of the Bye-laws).

The Presents received since the last Meeting were laid on the Table and the thanks of the Members ordered to be returned for the same.

From

*Anonymous* — Fair Play: Political Thoughts addressed to Moderate Men: by one of Themselves. 8vo. 1852.

*Bell, Jacob, Esq.* (*the Editor*) — The Pharmaceutical Journal for March, 1852. 8vo.

*Bowles, Vice-Admiral,* (*the Author*) — Thoughts on National Defence; 3rd Edition. 8vo. 1852.

*Brande, Professor, F.R.S.* — Chemical Gazette, Vol. I. — IX. 8vo. 1842-51.

*British Architects, Royal Institute of* — Proceedings for March, 1852. 4to.

*Editor* — The Medical Circular and General Medical Advertiser, Nos. 1 — 6, (and case). 4to. 1852.

*Civil Engineers, Institution of* — Proceedings for March, 1852. 8vo.
Proceedings, Vol. IX. Part 2. Vol. X. Part 1. 8vo. 1851-2.
List of Members, 1851. 8vo.

*Faraday, M. Esq.* — Monatsberichte der Königl. Preuss. Akademie zu Berlin, Jan. und Feb. 1852. 8vo.

*Franklin Institute, Philadelphia* — Journal, Vol. XXIII. No. 1. 8vo. 1852.

*Graham George, Esq.* (*The Registrar-General*) — Report of the Mortality of Cholera in England, 1848-9. 8vo. 1852.

*Hankey, Thomson, jun. Esq.* (*Governor of the Bank of England*) — Section of the Well sunk at the Bank of England, 1851.

*Holland, Henry, M.D., F.R.S., M.R.I.* (*the Author*) — Chapters on Mental Physiology. 8vo. 1852.

*Lawrence, Hon. Abbott* (*the American Minister, &c.*) — Second Report on Meteorology of the United States, 1843-5. obl. fol. 1850.

*London Library, Committee of the* — Catalogue of the London Library, Vol. II. 8vo. 1852.

*Lovell, E. B., Esq.* (*the Editor*) — The Monthly Digest for March, 1852. 8vo.

*Moxon, Edward, Esq., M. R. I.* — Poetical Works of John Keats, 16mo. 1851.
Life, Letters, and Literary Remains of John Keats, edited by Richard Monckton Milnes. 16mo. 1848.

*Nasmyth, James, Esq.* — Diagrams of Nasmyth's Patent Steam Hammer and Piledriver.

*Prosser, John, Esq.* (*Life-Sub. R.I.*) — Views in Syria, Palmyra, Antioch, &c. folio.

*Royal Society of London* — Proceedings, Vol. VI. Nos. 7 — 10. 8vo. 1852.

*Scoffern, John, M.B., F.S.A.,* (*the Author*) — Projectile Weapons of War and Explosive Compounds. 16mo. 1852.
A Treatise on the Sugar and Sugar Apparatus of the Great Exhibition. 12mo. 1852.

*Scrope, G. Powlett, Esq., M.P.* (*the Author*) — History of the Manor and Ancient Barony of Castle Combe, Wilts. 4to. 1852.

*University of London* — London University Calendar, 1852. 12mo.

*Wheatstone, Professor C., F.R.S., M.R.I.* (*the Author*) — Contributions to the Physiology of Vision, Part II. 4to. 1852.

*Wyld, George, M.D.,* (*the Author*) — The Liver the Regenerator or Hydrogenator in Animals, &c. 8vo. 1852.

## WEEKLY EVENING MEETING,

Friday, April 23.

W. Pole, Esq. M.A., F.R.S., Treasurer and Vice-President, in the Chair.

The Rev. Baden Powell, M.A., F.R.S., &c.

SAVILIAN PROFESSOR OF GEOMETRY, OXFORD,

### *On the Analogies of Light and Heat.*

The researches of Sir W. Herschel, Sir J. Leslie, M. De La Roche, and others, long since established the existence of well marked differences in character, not only between the radiation from the Sun and that from terrestrial sources, but even among these latter, according as the source was luminous or not: and this especially as regarded its transmissibility through various screens and the absorptive effect of different surfaces.

But the most striking peculiarity in the radiation from flame was established by Sir W. Herschel and afterwards extended to gas-lights by Mr. Brande, in that even at considerable *distances*, after passing through a *thick glass lens*, without heating it, the concentrated rays produced *heat on a blackened thermometer* at the focus, exactly as in the case of the solar rays.

This pointed to a peculiar distinction (also recognized by Sir J. Leslie) and shewed that *the mere proportion* of heat transmitted by a screen (as in De la Roche's experiments) was not the essential characteristic, but that further distinction as to the *specific nature* of the rays, was wanted. This want it was attempted in some measure to supply in some experiments by the author of this paper, (Phil. Trans. 1825) in which the *character of the different rays as to* TRANSMISSIBILITY through screens was examined IN COMBINATION *with the conditions of the* ABSORBING SURFACE.

This last is a point even yet little understood; but thus much is clear: —

(1) A certain peculiarity of *texture* in the external lamina is favourable to the absorption of radiant heat, probably in all cases.

(2) *Darkness of colour* is peculiarly favourable to the effect *for the Sun's rays*, and wholly overrules the first condition.

In terrestrial *luminous hot bodies* it does so to an extent sufficient to give very marked indications. But this (as the author shewed, in the experiments referred to), applies to *that portion only* of the compound rays, which is also *transmissible* through glass, the non-transmissible portion is subject wholly to the former condition, as are *all* the rays from *non-luminous* sources (as was shewn by Leslie and others).

Hence the distinction of *at least two species* of heating rays emanating at the same time from the same *luminous* source.

From the neglect of this distinction much confusion has been kept up: and statements involving such confusion have been repeated from one elementary treatise to another.

Again; notwithstanding that the experiments of Leslie and others on the *absorption* of heat from *non-luminous* sources, as well as those of Professor Bache on the *radiation from surfaces*, demonstrate that the effect has *no relation* whatever to *colour*, yet the contrary assertion has been often persisted in.

Again "dark heat" is often spoken of without recollecting that rays of the very same quality and properties exist in the compound radiation from *luminous* sources.

The conclusions drawn from later experiments, (performed with all the advantages derived from the beautiful invention of the thermo-electric instrument of Nobili,) in many instances, are still vague, from want of attention to the distinction of *different species of heat* emanating at the same time from the same source.

Melloni, in a most extensive and valuable series of experiments, taking as the sources of heat successively flame, incandescent metal, boiling mercury, and boiling water, and applying in each instance a long series of substances as screens, estimated the proportion of rays out of 100 stopped, which was very different for each screen and each source: evincing wide differences in "*diathermaneity*;" while *rock salt* alone was almost totally "diathermanous" to rays from all sources alike.

But we must still ask, what *species* of rays were those respectively stopped and transmitted? To take the *per centage* simply is ambiguous; the body of rays is not homogeneous; the property of transmissibility should be viewed in combination with other properties of the specific rays, such as those evinced in their relations to the texture or colour of the absorbing surface.

Nor is the ambiguity removed, though the difference of *source* is specially referred to, if the heterogeneity of rays from the *same* source be overlooked. The mere classification of sources into *luminous* and *non-luminous* will not suffice: still less a reference to their *temperatures:* it being perfectly well known that the *temperature of luminosity* is very different for different substances.*

Again Melloni has shewn that the *diathermaneity* is not proportional to *transparency*, by a classified series of transparent screens with the *lamp*.

It must however be recollected that the term "diathermaneity" is applied indiscriminately to a heterogeneous body of rays: out of which *some species of rays* are entirely stopped, others entirely transmitted; and the great differences in "diathermaneity" for heat

* References in detail to all the different researches here mentioned, will be found in the Author's Two Reports on the state of our knowledge of Radiant Heat in the British Association Reports, 1832 and 1840.

from different sources, which Melloni has also established, are nothing else than *absorption of* PECULIAR *rays* by each medium, not more anomalous than the corresponding absorptions of *luminous* rays by different transparent media so little as yet reduced to law.

While *rock salt* is analogous to colourless media for light, *alum* on the other hand is totally impermeable by heat from dark sources, and partially so by rays from the lamp; that is, wholly impermeable for that portion of the rays which are of the *same kind* as those from non-luminous sources, and permeable to the others.

By other sets of experiments Melloni shewed that rays from the lamp transmitted in different proportions by various screens and then equalized, were afterwards transmitted by *alum* in equally various proportions: or as he expresses it "possess the diathermancy peculiar to the substances through which they had passed."

But this implies no new property communicated to the rays. It shews that as *different specific rays* out of the compound beam were transmitted in each case by the first screen, alum, though impervious to the lower heating rays, is permeable by these higher rays; and in different degrees according to their *nature;* an effect simply dependent on the heterogeneity of the compound rays from a lamp.

Again with differently coloured glasses peculiar differences of diathermaneity were exhibited with rays from a lamp, incandescent metal, and the sun: but not more various or anomalous than the absorption of specific rays of light.

And besides considerations of this kind it must always be borne in mind that a *blackened surface* (like that which was used in all these experiments) itself is *unequally absorptive for the different rays.*

The solar heat being freely transmissible through all colourless transparent media along with the light, there would be no peculiar advantage in experimenting on the solar spectrum formed by a rock-salt prism. Melloni however with such a prism on interposing a thick screen of water, found the most heating rays (*i. e.* those at or beyond the red end) intercepted, as they are known to be by water: and this caused the position of the *relative* maximum to be apparently shifted higher up in the spectrum, even to the position of the green ray.

On the other hand many coloured glasses, he found, absorbed the rays in various proportions, yet they left the point of maximum heat unaltered: *i. e.* though variously absorptive for the higher rays, they were not of a nature to stop the lower, or most heating rays.

One result indeed is recorded which seems at variance with all other experiments on the solar rays: a peculiar green glass (tinged by oxide of copper) was found to absorb so entirely all the most heating rays that the remaining portion produced no heat, though when concentrated by a lens they gave a brilliant focus. Speaking generally however, these experiments only confirm what is on all hands admitted, *viz.* that the *illuminating* and *heating* powers follow very different laws, with relation to the different rays.

The grand discovery by Melloni of the true REFRACTION OF HEAT even of that kind which constitutes the whole radiation from dark sources, by means of the *rock salt* lens and prism, and its extension by Professor Forbes to the determination of the *index of refraction* ($\mu$) for the most heating rays from all sources both luminous and non-luminous, gave the first actual proof of the real analogy, of the propagation of heat by waves in an etherial medium: which was further carried out when it was shewn from Cauchy's theory that for different wave lengths ($\lambda$) there must be in every medium a certain *limit of all refrangibility:* that is, as we suppose ($\lambda$) to increase, large changes in ($\lambda$) will give continually smaller changes in ($\mu$), and when ($\lambda$) is very great compared with ($\Delta x$) the intervals of the molecules, then the index ($\mu$) assumes its limiting value which is not greatly below that for the extreme red ray, and with this, the index for the lowest heat coincides.

This is seen directly from the formula *

$\frac{1}{\mu^2} = P - Q\left(\frac{\Delta x}{\lambda}\right)^2 + R\left(\frac{\Delta x}{\lambda}\right)^4$ — &c., which when we suppose $\left(\frac{\Delta x}{\lambda}\right) = 0$ will have for its limiting value $\left(\frac{1}{\mu}\right) = \sqrt{P}$

The results from observation for Rock salt compared with this theory are as follows:

Rock Salt.

| rays | $\mu$ | |
|---|---|---|
| | obs. | theory |
| mean light | 1.558 | . . |
| red ray | 1.540 | . . |
| $\lambda = .000079$ | . . | 1.529 |
| dark hot metal | 1.528 | . . |
| Limit | . . | 1.527 |

But it is to the capital fact established by Professor Forbes, of the *polarization* of heat from *dark* sources (for with *luminous* sources little doubt could exist), with all its remarkable train of consequences, that the complete analogy with light is seen in the most uninterrupted point of view; — the transverse vibrations, the dipolarization, the consequent interferences, the production of circular and elliptic vibrations under the proper conditions, — to those familiar with the

* See the Author's Treatise "On the Undulatory Theory applied to the Dispersion of Light," &c. London, J. W. Parker, 1841, pp. 71-122.

wave-theory present an irresistible accumulation of proof of the identity of the rays of heat with a succession of waves in an etherial medium: exhibiting different properties in *some* dependence on their wave-lengths.

Among the most recent researches on the subject are those of Mr. Knoblauch (of which a translation is given in Taylor's Foreign Scientific Memoirs, Part xviii. and xix.) and they are not to be surpassed for extent and accuracy of detail.

One series is devoted to the examination of the alleged differences in radiation of heat *proportioned to the temperature* of the source. This as before observed is an untenable hypothesis, but Mr. Knoblauch distinctly refutes it by a series of experiments on alcohol flame, red hot metal, hydrogen flame and an argand lamp, whose *temperatures* are in the order of enumeration beginning with the highest: but the power of their heat to penetrate screens is found to follow exactly the reverse order. And even with lower stages of heat, the effects bear no proportion to the *temperatures* as such. Hence the effect is evidently not due to a mere extrication of the heat of temperature, but is of a peculiar kind. In a word, agreeably to the preceding remarks, the different species of rays, more or less compounded together in the several cases, exhibit their diversities of character in developing heat by their absorption. One very peculiar result is, that Platinum, at a stage intermediate between red and white heat, transmits through all the screens employed rather less heat than when at a red heat. That is, these intermediate rays are of such a wave-length as to be subject to a peculiar absorption by these screens: while at the same time possibly less of the former may be emitted.

In another section Mr. Knoblauch adverts to the effects of surfaces on the absorption of rays, and particularly remarks (p. 205); "The experiments of B. Powell and Melloni have shewn that one "and the same body is not uniformly heated by rays from different "sources, which exert the same direct action on a blackened thermo-"scope;" a statement which does not very intelligibly express any conclusion of the author's. Mr. Knoblauch however supports it by elaborate experiments shewing, as might be anticipated, that an argand lamp affects a surface of carmine less, and one of black paper more, while a cylinder heated to 212° affects the carmine more and the black paper less.

Another extensive series, on the effect of surfaces on radiation, is directed to shew that the effect is independent of the source whence the heat so radiated, was originally obtained.

Among the very multifarious results referring to screens and surfaces obtained by Mr. Knoblauch, it can here only be remarked that none of those varied facts appear to present anything *at variance* with the principles here advocated, while in the general conclusions which he indicates at the close of his memoir, the author though professedly avoiding all hypothesis, yet distinctly intimates his conviction of the heterogeneity of the heating rays increasing as the condition of the source rises in the scale from a low heat up to lumi-

nosity or combustion: and that the diversities of heating effect on different media, are due to a selective absorption of particular species of rays, from peculiarities in the nature of those substances, and analogous to the absorption of particular rays of light by coloured media.

It must not however be omitted to notice, however briefly, another recent set of researches of high interest, those of M. Silberman; in which (among others) the very remarkable fact is established, that on transmitting a narrow ray of heat from a heated wire, through *rock crystal*, there is a singular difference according as the ray passes *parallel* or *perpendicular* to the axis of the crystal: the effect being indicated by having the further side of the crystal coated with a fine composition of wax, the portion of which in the direction of the ray is melted in a *circular* form in the first instance and in an *elliptical* in the second.

The general fact of the heterogeneity of heating rays, especially from luminous sources, is fully recognized by Melloni as in some sense the conclusion from all his experiments.

The hypothesis that this heterogeneity consists simply in differences of wave-length would seem a probable one; though it is still possible, as Professor Forbes suggests, that some other element may also enter into the conditions.

This view has been extended by M. Ampère so as to refer both luminous and heating effects to the *same* rays: — a view controverted by Melloni, chiefly on the ground, evinced by several classes of experiments, that *the intensity of the heating effect* (especially in the solar rays) *follows no proportion to that of illumination;* an argument which really amounts to little unless the theory obliged us to infer that the amount of illumination must follow the *same law* as that of heat; which it manifestly does not; since the nature of the effect in the one case is wholly dependent on the unknown constitution of the optic nerve; according to which some precise proportion of the impinging vibrations, with a particular wave-length, is that which gives the greatest perfection of *vision:* while for *heat* the effect has no reference to such peculiar conditions, but is dependent in some way on longer wave-lengths, and probably more simply connected with the intensity or amplitude of the vibrations.

On this theory our view of the case would be thus: —

A body heated below luminosity begins to give out rays of large wave-length only. As it increases in luminosity it continues to send out these, and at the same time others of diminishing wave-lengths, till at the highest stage of luminosity it gives out rays of all wave-lengths from those of the limit greater than the red end of the spectrum, to those of the violet end, or possibly less.

Rays of all these species are transmissible and refrangible by Rock salt; and many of them with numerous specific distinctions by other media.

They are all *more* or *less* capable of exciting *heat* when absorbed or *stopped:* though in some the effect is perhaps insensible. Both this property and that of their transmissibility seems to depend in some way *on the wave-length,* though in no simple ratio to it.

The absorptive effect due to *texture* of surfaces has some *direct* relation to the magnitude of the wave-length, especially near the limit. While that due to *darkness of colour* is connected with shorter wave-lengths such as belong to rays within the limits of the *light spectrum:* and in any case when a ray impinges on any absorbing substance, its vibrations, being stopped, communicate to the molecules of the body vibratory movements of such a kind as constitute heat of temperature.

The peculiar molecular constitution of bodies which determines their permeability or impermeability to rays of any species, gives rise to all the diversities of effect, whether luminous or calorific. We thus escape all such crude ideas, at once difficult and unphilosophical, as those either of two distinct material emanations producing respectively heat and light, or of a conversion of one into the other; and obtain a view far more simple and consistent with all analogy.

[B. P.]

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In the Library were exhibited: —

Dr. W. B. Herapath's Iodine of Disulphate of Quinine (a crystalline substance which has the power of Polarizing a ray of Light like a tourmaline. [Exhibited by Col. P. J. Yorke, M.R.I.]

Specimen of Decorative Drawing (by a Lady). [Exhibited by C. B. Mansfield, Esq., M.R.I.]

Specimens of Carving in Wood, by Mr. W. G. Rogers.

Wire Models illustrating Geometry, Crystallography, &c. [Exhibited by Mr. Tennant.]

Plan of Battle at Borodino — Nelson's hat — Antique Military Accoutrements, &c. [From The United Service Institution.]

Ancient sword of State formerly carried before the Bishop of Treves. [Exhibited by Messrs. Hunt and Roskell.]

[FOR THE USE OF MEMBERS.]

# Royal Institution of Great Britain.

1852.

## EXTRA EVENING MEETING,

Wednesday, March 31.

SIR CHARLES LEMON, BART, M.P., F.R.S.
in the Chair.

M. P.-H. BOUTIGNY (d'Evreux).

*Etudes sur les Corps à l'état sphéroïdal.*

LES Phénomènes qui se rapportent à cette partie de la Physique ont du être entrevus dès la plus haute antiquité. Le premier qui fit chauffer un silex, un morceau de granit ou un métal quelconque, et qui laissa tomber accidentellement ou volontairement sur sa surface quelques gouttes d'eau dut remarquer que cette eau ne se comportait pas comme lorsqu'on l'échauffait dans les conditions ordinaires. En remontant aux traditions les plus reculées, peut-être trouvait-on la trace de cette observation dans ces paroles du Livre de *La Sagesse* (verset 19 du chap. xix) : "Le feu surpassant sa propre "nature, brûlait au milieu de l'eau, et l'eau oubliant la sienne ne "l'éteignait point." Au moyen âge, les verriers paraissent avoir connu cette propriété et en avoir fait une application assez ingénieuse à leur art. Quelle que soit l'antiquité de cette remarque, on peut dire que les phénomènes qui s'y rapportent n'ont été réellement observés que vers le milieu du dernier siècle, et à peu près dans le même tems par Eller* et par Leidenfrost.† Depuis lors le petit nombre de physiciens qui se sont occupés de ce phénomène, n'ont presque rien ajouté ni aux expériences qui l'eussent reproduit sous de nouvelles formes, ni à son explication théorique.

Tout le monde a observé que lorsqu'on laisse tomber quelques gouttes d'eau dans une capsule rougie au feu, cette eau, loin de se répandre sur le métal et de le mouiller, prend la forme de globules qui roulent à sa surface sans y adhérer. Voilà l'expérience vulgaire qui est le point de départ de toutes les recherches de cet ordre. Dans les cours de Physique, on s'était contenté de dire que l'eau,

* Histoire de l'Académie de Berlin, 1746, page 42.

† De aquæ communis qualitatibus. Duisbourg, 1796.

mise en contact avec un corps incandescent, n'adhérait point à sa surface et s'évaporait plus lentement que lorsque le même corps était porté seulement à la température où le liquide entrait en ébullition; mais on n'avait donné de ce phénomène aucune explication satisfaisante.

Lorsqu'on projette quelques gouttes d'eau sur une plaque d'argent légèrement concave, à la température ordinaire, le liquide en mouille la surface et y adhère par tous ses points en contact. Si l'on échauffe cette plaque, au moyen d'une lampe à l'alcool, l'eau, parvenue à la température de 100 degrés, se convertit en vapeur et passerait tout entière à cet état dans un temps déterminé; mais si l'on continue d'élever la température de la plaque, au de la de 142° par exemple, le phénomène change de nature; l'eau cesse d'adhérer à la plaque d'argent, elle ne s'étend plus à sa surface, et semble se replier sur elle-même en prenant la forme d'un sphéroïde applati de haut en bas. La température jusqu'alors fixée à 100°, s'abaisse subitement à $+ 100^{\circ} - x$, et reste fixe à ce degré, quelqu' effort que l'on fasse et en plaçant l'appareil dans les conditions calorifiques les plus énergiques. L'évaporation loin d'être augmentée par cette élévation excessive de température, diminue au contraire à ce point qu'une même quantité d'eau pour se réduire en vapeur, exige cinquante fois plus de temps que lorsqu'elle est soumise à la température de l'ébullition. Enfin il s'établit dans le sphéroïde des ondulations régulières, entrecroisées, parfaitement visibles et qui offrent la plus grande analogie avec celles qui sont produites par les corps sonores mis en vibration. La même expérience répétée avec la plupart des autres liquides, donne des résultats qui ne varient que proportionnellement aux limites respectives de leur point normal d'ébullition.

Tel est le phénomène principal: telles sont les nouvelles lois auxquelles obéissent les liquides dès qu'ils cessent d'être soumis à la loi ordinaire de l'équilibre de température, loi qui ne s'exerce que dans des limites déterminées et assez restreintes.

Voici les expériences à l'aide desquelles on peut rendre parfaitement sensibles les moindres détails de ce phénomène. Que l'on prenne un corps très combustible, de l'azotate d'ammoniaque, par exemple, qui s'enflamme à une assez basse température, et qu'on le projette sur une capsule de platine, rougie a l'aide d un eolipyle; ce corps entrera en fusion, prendra la forme sphéroïdale, ne brûlera point et ne se décomposera qu'avec beaucoup de lenteur. Retirez alors l'eolipyle, laissez refroidir la plaque jusqu'au degré où cet azotate s'enflamme ordinairement, aussitôt il fusera et s'enflammera: singulier exemple d'un corps très combustible qui ne brûle point dans les circonstances qui sembleraient les plus favorables à sa combustion et qui brûle dès qu'on le soustrait à l'action d'une trop vive chaleur.

Si au lieu d'azotate d'ammoniaque, on projette de l'iode sur une plaque rougie, tant que celle-ci sera très chaude, les vapeurs d'iode seront à peine visibles; mais si on la laisse refroidir, l'iode s'étalera à la surface en donnant naissance aux belles vapeurs violettes qui le

caractérisent. Enfin, lorsqu'on verse dans une capsule rougie quelques grammes d'eau distillée, le liquide passe rapidement *à l'état sphéroïdal*; il n'adhère point à la capsule, n'entre pas en ébullition et s'évapore lentement. Si l'on plonge dans le sphéroïde la boule d'un thermométre, celui-ci accusera invariablement une température plus basse que celle de l'eau bouillante; mais si on laisse refroidir la capsule, le thermométre se relevera à 100°, l'eau entrera en ébullition tumultueuse et s'évaporera rapidement dans le tems et les conditions ordinaires.

Ces faits nouveaux et singuliers semblent en opposition manifeste avec les lois connues de la chaleur; d'autres expériences qui sont comme les corollaires des précédentes peuvent servir à montrer toute la portée de ces observations. Ainsi les lois qui régissent les corps passés à l'état sphéroïdal peuvent expliquer certains cas d'explosion des chaudières à vapeur. Si l'on verse deux grammes d'eau distillée dans une petite chaudière sphérique dont le fond est chauffé par un eolipyle et qu'on la bouche fortement; tant que l'eau sera maintenue à l'état sphéroïdal dans son intérieur, il n'y aura pas d'explosion: mais si l'on retire l'eolipyle, un léger bruissement ne tarde pas à annoncer le passage de l'eau à l'état liquide, puis à l'état de vapeur et le bouchon sera lancé violemment dans l'air avec explosion. De même si l'on met de l'eau dans une chaudière d'essai et si on la soumet à une haute température, l'eau ne tardera pas à bouillir et à donner des torrents de vapeur. Si l'alimentation est négligée par une cause quelconque et que la chaudière vienne à rougir, l'eau qu'on y introduira alors acquerra des propriétés nouvelles: elle ne mouillera plus les parois de la chaudière, elle ne s'échauffera pas au dela de 98 dégrés et ne donnera que très peu de vapeurs. Mais si l'on diminue l'intensité des feux, ou bien si l'on introduit une grande masse d'eau froide dans la chaudière, cette eau s'étendra sur les parois, se réduisa brusquement en vapeurs, dont la tension considérable entrainera infailliblement la rupture et l'explosion de la chaudière.

L'abaissement de la température dans les corps passés à l'état sphéroïdal est une loi générale que l'on peut constater en plongeant la boule d'un thermomètre dans des sphéroïdes d'alcool absolu, d'oxide et de chlorure d'ethyle, d'acide sulfureux et d'un grand nombre d'autres corps. Ce phénomène a donné lieu à un résultat tout-à-fait imprévu et des plus remarquables. On sait que l'acide sulfureux anhydre; liquéfié, entre en ébullition à 11° au-dessous de zéro; l'auteur ayant versé quelques grammes de cet acide dans une capsule de platine rougie au feu, (l'air environnant étant légèrement humide,) l'acide sulfureux prit aussitot une apparence opaline, perdit sa transparence, se solidifia et l'opérateur vit avec étonnement que ce solide n'était autre chose qu'un morceau de glace. Pour varier l'expérience, il versa dans le même acide à l'état sphéroïdal quelques gouttes d'eau distillée qui se congelèrent rapidement, enfin un très petit matras contenant un gramme d'eau distillée ayant été plongé dans le même

sphéroïde et retiré au bout d'une demi minute contenait également un petit morceau de glace. Pour montrer que les liquides passés à l'état sphéroïdal n'adhérent plus à la surface du corps échauffant, on fait tomber sur une capsule d'argent ou de cuivre, rougie, de l'acide azotique très concentré; celui-ci roule sur la capsule sans l'attaquer; mais si on laisse refroidir la capsule, il arrive un moment où l'acide attaque le métal avec violence. Autre exemple: un cylindre d'argent chauffé à blanc, étant plongé dans un verre d'eau, on peut voir très distinctement qu'il n'y a pas de contact et que l'eau est maintenue à une certaine distance du cylindre, à mesure que l'équilibre s'établit entre le métal et l'eau, le contact a lieu, un léger sifflement se fait entendre et l'eau entre vivement en ébullition.

Mais ce n'est point à des résultats physiques que se bornent ces curieux phénomènes. Il est évident que ce nouveau mode d'action doit donner lieu à des réactions, à de nouveaux moyens d'analyse et de synthèse chimiques. Certains corps qui ne se décomposent pas à la température de l'ébullition, se décomposent dès qu ils sont amenés à l'état sphéroïdal; d'autres mis en contact sous l'influencc de ce nouvel état moléculaire, se prêtent à de nouvelles combinaisons. Le vin, l'alcool, l'esprit de bois, soumis à l'état sphéroïdal, associent leurs éléments dans un nouvel ordre; l'ether se décompose en dégageant de l'aldehyde; le chlorure d'ethyle décompose l'azotate d'argent; l'ammoniaque dans le méme état dissout l'iode; les huiles essentielles, la naphtaline, l'acide benzoique, l'acide citrique et une foule d'autres substances se transforment et donnent naissance à d'autres produits. Ces exemples suffisent pour montrer tout le parti que les chimistes peuvent tirer de ce nouveau mode d'expérimentation et tout ce qu'il promet dans l'avenir de resultats curieux et inattendus.

Cette forme que prennent les corps soumis à une très haute température et à laquelle se rattachent de nouvelles lois physiques, serait, selon l'auteur de ces recherches, une quatrième modification de la matière, qui ferait suite aux états solide, liquide, gazeux et il lui imposa provisoirement le nom *d'état sphéroïdal.* Il croit en trouver l'origine et la cause dans les vibrations que le calorique communique à la matière. Le passage d'un état à l'autre s'expliquerait par la coïncidence ou la non-coïncidence du mouvement ondulatoire qui a lieu dans le liquide et dans le corps échauffant. L'analogie des vibrations permettrait le contact et l'adhérence, tandis que leur oppposition les détruirait. L'adhérence une fois détruite, le liquide se replierait sur lui-même, comme l'eau sur une surface graisseé, comme le mercure sur un plan de marbre, ses molécules se rapprocheraient naturellement de la molécule centrale.

Parmi les propriétés des corps amenés à l'état sphéroïdal, il en est deux auxquelles l'auteur attache une importance spéciale. L'une est le pouvoir qu'ils acquièrent de refléchir le calorique, en se constituant dans un état d'équilibre stable; l'autre est cette faculté de se replier, en vertu d'une attraction particulière vers leur

molécule centrale, comme s'ils étaient réduits à un point matériel isolé dans l'espace, tout en restant soumis à l'attraction terrestre, en sorte que leur forme naturellement sphérique se comprime dans le sens du rayon de la terre. L'auteur tire de ces observations des conséquences fort étendues, applicables à la géologie, à la mécanique terrestre, etc. etc. Il pense que de grandes vérités découleront d'une étude plus approfondie de ces phénomènes. Il pense que la philosophie des sciences fera un pas de géant quand les géomètres analyseront ce phénomène qui a du se produire à la surface du globe sur une grande échelle à l'époque de son incandescence. Peut-être se produit-il encore à la surface du noyau incandescent de la terre.

Les recherches relatives à l'état sphéroïdal peuvent conduire à l'explication d'un autre ordre de phénomènes. En l'an 241 Sapor, ou Chapour ordonna aux Mages de faire tout ce qui serait en leur pouvoir pour persuader et ramener les dissidents à la foi de leurs ancêtres. Un des Pontifes du culte dominant, Abdurabâd Mabrasphand, offrit de se soumettre dans ce but à ce qu'il appela l'épreuve du feu. Il proposa que l'on rêpandit sur son corps nud dix-huit livres de cuivre fondu sortant de la fournaise et tout ardent, à condition que s'il n'était point blessé, les incrédules se rendraient à ce prodige. On dit que l'épreuve se fit avec un plein succès et qu'ils furent tous convertis. Les récits merveilleux sur les épreuves par le feu, au moyen âge, et sur les hommes incombustibles dont quelques-uns se montrent encore sur les places publiques se retrouvent partout. Tout le monde a vu ou entendu parler de ces hommes qui courent les pieds nus sur la fonte incandescente, qui plongent la main dans le plomb fondu ou qui appliquent sur leur langue une lame de fer rougie au feu. Ce fait n'aura plus rien d'extraordinaire, si l'on remarque que l'eau, à l'état spheroïdal, réflechit le calorique rayonnant et que sa température n'atteint jamais celle de son ébullition. Ainsi, lorsqu'on plonge la main, légèrement humide, dans un métal en fusion, l'humidité qui la recouvre passe à l'état sphéroïdal, refléchit le calorique rayonnant et ne s'échauffe pas même jusqu'à la température de l'eau bouillante. L'étude du même phénomène donne donc l'éxplication naturelle de ces faits en apparence si extraordinaires, qui peuvent aujourdhui se répéter dans les amphithéatres et les cours publics sans aucun danger pour l'opérateur.

On a vu plus haut que l'eau à l'état sphéroïdal jouait un rôle important dans l'une des causes des explosions fulminantes des chaudières à vapeur. L'auteur poursuivant ses études dans cette direction est parvenu à créer un nouveau système de générateur à vapeur, Le principe général de ce nouveau mode de génération de la vapeur réside dans la division extrême de l'eau au moyen de diaphragmes percés de petits trous et superposés dans l'intérieur de la chaudière. On sait que la matière ne s'évapore que par ses surfaces.

Une chaudière de ce système ayant seulement un demi mètre carré de surface de chauffe évapore de 38 à 40 litres d'eau par heure sous la pression de 10 atmosphères. Dans l'ancien système la même chaudière ne saurait évaporer plus de 10 litres d'eau dans le même temps et sous la même pression. Le rapport est donc : : 1 : 4.

Selon l'auteur, ce nouveau générateur serait absolument inexplosible et destiné à jouer un rôle important dans notre civilisation actuelle en créant une *force domestique*, souvent *gratuite*. En effet, le foyer qui imprimerait le mouvement aux outils de l'atelier donnerait en même temps la chaleur nécessaire, dans tous les climats, à l'existence de l'ouvrier et de sa famille. Ce serait donc à la fois un source de calories et de dynamies avec un seul et même foyer.*

[P.-H. B.]

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## WEEKLY EVENING MEETING,

Friday, April 30.

WILLIAM RICHARD HAMILTON, Esq., F.R.S., F.S.A., Vice President, in the Chair.

THOMAS H. HUXLEY, F.R.S., Assistant-Surgeon, R.N.

*Upon Animal Individuality.*

THE Lecturer first briefly described the structure of the Diphydæ and Physophoridæ — pointing out the general conformity of these animals with the common Hydra.

They differ, however, in this important respect; that the body in which the eggs are developed is in Hydra, a simple process; while in the Diphydæ and Physophoridæ the corresponding body presents every degree of complication from this form, to that of a free-swimming, independent "Medusa."

Still more striking phenomena were shewn to be exhibited by the Salpæ. In this genus each species has two forms. In the example chosen these forms were the S. democratica, and the S. mucronata; the former is solitary and never produces ova, but developes a peculiar process the "gemmiferous tube;" upon which, and from which the associated Salpæ mucronatæ are formed by budding.

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* On trouvera des détails plus étendus sur ce sujet dans la 3e édit. d'un opuscule que l'auteur espère pouvoir publier prochainement et qui a pour titre: *Nouvelle Branche de Physique ou Etudes sur les corps à l'Etat sphéroïdal.*

Each of these carries a single ovum, from which the first form is again developed.

The Salpa mucronata, which is thus produced from the Salpa democratica, is just as highly organized as the latter. It has as complete a circulatory, nervous, and digestive apparatus, and moves about and feeds as actively; no one unacquainted with its history would dream of its being other than a distinct individual animal, and for such it has hitherto passed.

But the Salpa mucronata has exactly the same relation to the S. democratica that the free-medusiform egg-producing body of Physalia or Velella has to the Physalia or Velella; and this free-medusiform body is homologous with the fixed medusiform body of Diphyes; which again is homologous with the semi-medusiform, fixed body of a Tubularia and with the egg-producing process of the Hydra.

Now as all these bodies are homologous with one another, one of two conclusions is possible; either, considering the Salpa mucronata to be an individual, we are logically led to look upon the egg-producing process of Hydra as an individual also, which seems absurd.

Or starting with the assumption that the egg-producing process of Hydra is a mere organ, we arrive at the conclusion that the Salpa mucronata is a mere organ also: which appears equally startling.

The whole question appears to turn upon the meaning of the word "individual."

This word the Lecturer endeavoured to shew always means, merely, "a single thing of a given kind."

There are, however, several kinds of Individuality.

*Firstly*, there is what may be called *arbitrary* individuality, which depends wholly upon our way of regarding a thing, and is therefore, merely temporary: such is the individuality of a landscape, or of a period of time; a century for instance.

*Secondly*, there is an individuality which depends upon something else than our will or caprice; this *something* is a fact or law of co-existence which cannot be materially altered without destroying the individuality in question.

Thus a Crystal is an individual thing in virtue of its form, hardness, transparency, and other co-existent qualities; pound it into powder, destroy the co-existence of these qualities, and it loses its individuality.

*Thirdly*, there is a kind of individuality which is constituted and defined by a fact or law of succession. Phenomena which occur in a definite cycle are considered as one in consequence of the law which connects them.

As a simple instance we may take the individuality of the beat of a pendulum. An individual beat is the sum of the successive places of the bob of the pendulum as it passes, from a state of rest to a state of rest again.

Such is the individuality of living, organized beings. Every or-

ganized being *has* been formless and will again be formless; the individual animal or plant is the *sum* of the incessant changes, which succeed one another between these two periods of rest.

The individual animal is one beat of the pendulum of life, birth and death are the two points of rest, and the vital force is like the velocity of the pendulum, a constantly varying quantity between these two zero points. The different forms which an animal may assume correspond with the successive places of the pendulum.

In man himself, the individual, zoologically speaking, is not a state of man at any particular moment as infant, child, youth or man; but the sum of all these, with the implied fact of their definite succession.

In this case, and in most of the higher animals, the forms or states of the individual are not naturally separated from one another: they pass into one another, undistinguishably.

Among other animals, however, nature draws lines of demarcation between the different forms; thus, among insects the individual takes three forms, the caterpillar, the chrysalis, and the butterfly. These do not pass into one another insensibly, but are separated by apparently sudden changes; each change being accompanied by a separation of the individual into two parts. One part is left behind and dies, it receives the name of a skin or cast; the other part continues the existence of the individual under a new form.

The whole process is called Ecdysis: it is a case of what might be termed *concentric* fission.

The peculiarity of this mode of fission is; that of the two portions into which the individual becomes divided at each moult, one is unable to maintain an independent existence and therefore ceases to be of any importance; while the other, continues to carry on all the functions of animal life and to represent in itself the whole individuality of the animal. From this circumstance there is not objection to any independent form being taken for, and spoken of as the whole individual, among the higher animals.

But among the lower animals the mode of representation of the individual is different and any independent form ceases, in many cases, to represent the whole individual; these two modes, however, pass into one another insensibly.

The best illustration of this fact may be taken from the development of the Echinodenus, as it has been made known by the brilliant discoveries of Professor Müller.

The Echinus lividus stands in the same relation to its Pluteus, as a butterfly to its caterpillar; in the course of development only a slight ecdysis takes place, the skin of the Pluteus becoming for the most part converted into the skin of the Echinus.

But in Asterias, the Bipinnaria which corresponds with the Pluteus, gives up only a portion of its integument to the developed Asterias; the remaining and far larger portion lives for a time after its separation as an independent form.

The Bipinnaria and the Starfish, are as much forms of the same individual as are the Pluteus and Echinus or the caterpillar and butterfly; but here the development of one form is not necessarily followed by the destruction of the other, and the individual is, for a time at any rate, represented by two co-existing forms.

This temporary co-existence of two forms of the individual might become permanent if the Asterias, instead of carrying off the intestinal canal of the Bipinnaria, developed one of its own; and this is exactly what takes place in the Gyrodactylus, whose singular development has been described by Von Siebold.

But the case of the Gyrodactylus affords us an easy transition to that of the Trematoda, the Aphides, and the Salpæ, in which the mutual independence of the forms of the individual is carried to its greatest extent; so that even on anatomical grounds it is demonstrable that the difference between the so called "skin" of the caterpillar, the free Bipinnaria, and the Salpa democratica is not in kind, but merely in degree.

Each represents a *form* of the individual; the amount of independent existence of which a form is capable, cannot affect its homology as such.

The Lecturer then proceeded to point out that the doctrine of the "Alternation of Generations" and all theories connected with it, rest upon the tacit or avowed assumption "that whatever animal form has an independent existence is an individual animal," a doctrine which, he endeavoured to shew, must if carried out, inevitably lead to absurdities and contradictions, as indeed Dr. Carpenter has already pointed out.

There is no such thing as a true case of the "Alternation of Generations" in the animal kingdom; there is only an alternation of true generation with the totally distinct process of Gemmation or Fission.

It is indeed maintained that the latter processes are equivalent to the former; that the result of Gemmation as much constitutes an individual, as the result of true Generation; but in that case the tentacles of a Hydra, the gemmiferous tube of a Salpa, nay, the legs of a Centipede or Lobster must be called individuals.

And if it be said that the bud must have in addition the power of existing independently, to constitute an individual; there is the case of the male Argonaut, which has been just shewn by H. Müller to have the power of detaching one of its arms (a result of gemmation) which then leads a separate existence as the Hectocotylus.

Without a misuse of words, however, no one would call this a separate individual.

In conclusion the Lecturer stated his own views thus:

The individual animal is the sum of the phenomena presented by a

single life: in other words, it is, all those animal forms which proceed from a single egg, taken together.

The individual is represented in very various modes in the Animal Kingdom: these modes pass insensibly one into the other, in nature; but for purposes of clear comprehension they may be thus distinguished and tabulated.

*Representation of the Individual.*

I. By Successive Inseparable Forms.

*Ascaris.* A. Forms little different = Growth.

*Triton.* B. Forms markedly different = Metamorphosis.

II. By Successive Separable Forms.

1. *Earlier Forms not Independent.*

*Cockroach.* A. Forms little different = Growth with Ecdysis.

*Beetle.* B. Forms markedly different = Growth with Metamorphosis.

2. *Earlier Forms partially Independent.*

*Starfish.*

III. By Successive and Co-existent Separable Forms.

| *a. External Gemmation.* | | *b. Internal Gemmation.* |
|---|---|---|
| A. Forms little different. | | All the forms produce eggs. |
| *Nais.*<br>*Hydra.* | } | *Gyrodactylus.* |
| B. Forms markedly different. | | Last forms only produce eggs. |
| | *** Last Forms produced. | |
| | Generally: | |
| *Medusa.* | } | *Fluke.* |
| | Locally: | |
| *Salpa.* | } | *Aphis.* |

These various modes of Representation of the Individual are ultimate facts. One is neither more nor less wonderful or explicable than another; any theory which pretends to account for the Successive and Co-existent forms of the Aphis-individual, must also account for the Successive forms of the Beetle-individual or of the Horse-individual — since they are phenomena of essentially the same nature.

When the forms of the Individual are independent it becomes desirable to have some special name by which we may denote them so as to avoid the incessant ambiguity of the two senses of the word individual. For these forms the Lecturer some time ago proposed the name "Zöoid." Thus the Salpa-individual is represented by two Zöoids; the Fluke by three; the Aphis by nine or eleven, &c.

The use of this term is of course a mere matter of convenience and has nothing to do with the question of Individuality itself.

[T. H. H.]

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In the Library were exhibited: —

Leadbeater's Cockatoo; and Australian Birds. [Exhibited by Messrs. Leadbeaters.]

Specimens of the Flora of South Africa, recently brought over by Mr. P. Wicks.

Idol in Granite — Clay heads and Figures, from the Pyramids at Mexico — Mediæval Copper Vase and Spoon — Chinese Compass, and Cup, &c.— Specimen of Ancient Papyrus — Handle of Knife, in carved wood (from Strawberry-hill) — "Eve," in Roman Bronze — Head of a Faun, from Carthage. [Exhibited by Dr. W. V. Pettigrew, M. R. I.]

View of a Mountain Stream, sketched in the Tropics, by P. W. Justyne, Esq.

Greyhounds in Bronze — Inlaid Marble Table from Derbyshire — Two Septaria Slabs from the Oxford Clay — Two Marble Vases copied from the Etruscan — Beautiful Specimen of Gold in Quartz, from South Australia (value £70) — Stereoscope with two slides of Minerals, by Mr. Tennant.

Minerals and other Objects, from the Royal Institution Museum.

Mr. C. Varley exhibited by the Microscope, Embryo Snails, shewing the action of the heart, &c., the circulation of the Sap in the Nitella, and the Trumpet-shaped animalcules.

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## ANNUAL MEETING.

Saturday, May 1.

William Pole, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

The Annual Report of the Committee of Visitors on the State of the Institution was read and adopted.

Thanks were voted to the President, Treasurer, and Secretary, to the Committees of Managers and Visitors, and to Professor Faraday, for their services to the Institution during the past year.

The following Gentlemen were unanimously elected as Officers for the ensuing year: —

President — The Duke of Northumberland, F.R.S.
Treasurer — William Pole, Esq. M.A. F.R.S.
Secretary — Rev. John Barlow, M.A. F.R.S.

### Managers.

William Wilberforce Bird, Esq.
William Thomas Brande, Esq. F.R.S.
B. Bond Cabbell, Esq. M.P. F.R.S
Capt. Henry John Codrington, R.N.
J. Griffith Cole, Esq. M.A.
George Dodd, Esq. M.P. F.S.A.
Sir Charles Fellows.
Aaron Asher Goldsmid, Esq.
William Robert Grove, Esq. M.A. F.R.S.
Lord Londesborough, K.C.H. F.R.S.
George Moore, Esq. F.R.S. F.S.A.
Frederick Pollock, Esq. M.A.
Lewis Powell, M.D.
John Webster, M.D. F.R.S.
Professor C. Wheatstone, F.R.S.

### Visitors.

J. G. Appold, Esq.
J. C. Burgoyne, Esq.
William Carpmael, Esq.
Thomas Davidson, Esq.
Walter Ewer, Esq. F.R S.
Augustus Bozzi-Granville, M.D. F.R.S. F.L.S.
Col. J. G. Griffith.
Sir John Hall, Bart. F.R.S.
John Hennen, M.D.
Edward Kater, Esq. F.R.S.
Thomas Little, Esq.
Lord Lovaine.
Edward Meryon, M.D.
William Noble Rule, Esq.
Alfred S. Taylor, M.D. F.R.S.

## GENERAL MONTHLY MEETING,

Monday, May 3.

LEWIS POWELL, M. D. in the Chair.

John George Appold, Esq.
John George Dodson, Esq.
William Wyndham Horner, Esq.
Francis Lloyd, Esq.
Rev. Cyril Page.

were *admitted* Members of the Royal Institution.

Wentworth William Buller, Esq.
Edw. R. Drury, Esq.
Richard Jennings, Esq.
Augustus Oliver Shakspeare Massey, Esq.
Rev. Frederick D. Maurice,

were duly *elected* Members of the Royal Institution.

WILLIAM THOMAS BRANDE, Esq., F.R.S.L. & E. was unanimously elected Honorary Professor of the Royal Institution.

The Secretary reported, that the Managers had acceded to a proposal from Dr. JOHN CONOLLY to deliver a Course of Twelve Lectures "on Insanity," on Mondays and Wednesdays at 4 o'clock, P.M. commencing on Wednesday, May 5th.

The Presents received since the last Meeting were laid on the Table and the thanks of the Members returned for the same.

FROM

*Actuaries of Great Britain, Institute of.* — Constitution and Laws of the Institute. 8vo. 1851.
The Assurance Magazine, Nos. 5, 6, 7. 8vo. 1852.
*Architects, Royal Institute of British* — Proceeding for April, 1852. 4to.
*Asiatic Society of Bengal* — Journal, No. 224. 8vo. 1852
*Astronomical Society, Royal* — Monthly Notices, Vol. XII. No. 4. 8vo. 1852.
*Bell, Jacob, Esq. (the Editor)* — The Pharmaceutical Journal for April, 1852. 8vo.
*Cambridge Philosophical Society* — Transactions, Vol. IX. Part 2. 4to. 1852.
*Chemical Society* — Quarterly Journal, No. 17. 8vo. 1852.
*Civil Engineers, Institution of,* — Proceedings for April, 1852. 8vo.
*Editor* — The Athenæum for March, 1852. 4to.
*Editor* — The Medical Circular for April, 1852. 8vo.
*Ellis, Messrs. (Exeter)* — Map shewing the Time, kept by Public Clocks in Various Towns in Great Britain. (April, 1, 1852)
*Faraday, Professor* — Text-book of Mechanical Philosophy, by the Rev. R. Walker, M. A., F. R. S., Part I. Mechanics. 16mo. 1851.
Kaiserliche Akademie, Wien: — Denkschriften, Math.-Nat. Classe, Dritter Band, Erste Lieferung. 4to. 1851.
Sitzungsberichte, Math.-Nat. Classe, VII Band; 3, 4, 5 Heft. 8vo. 1851-2.
Phil.-Hist. Classe, VII Band; 3, 4, 5 Heft. 8vo. 1851-2.

*Faraday, Professor* — continued:
Archiv für Kunde Osterreichischer Geschichtsquellen, VII Band; 1 und 2 Heft. 8vo. 1851.
Notizenblatt, Nos. 19—24, 1851;— Nos. 1, 2, 1852. 8vo.
Monumenta Linguæ Paleoslovenicæ e Codice Suprasliensi, edidit F. Miklosich. 8vo. Vindobonæ, 1851.
Versuch einer Geschichte der Pflanzenwelt, von Dr. F. Unger. Wien, 1852.
Systema Helminthum auctore Carolo Mauritio Diesing. Vol. II. Vindobonæ, 1851.

*Her Majesty's Government (by Sir H. De la Beche)*— Records of the School of Mines and of Science applied to the Arts, Vol. I. 8vo. 1852.
*(By Col. Edw. Sabine)* — Magnetical and Meteorological Observations at Hobarton, Vol. II. 4to. 1852.

*Holdsworth, A. H. Esq.* — Holdsworth's Water-Bulkheads, for reducing the Temperature and Arresting Fire in Ships or Vessels. 8vo. 1852.

*Hon. East India Company* — Bombay Meteorological Observations for 1847. 4to. 1851.

*Horticultural Society of London* — Journal, Vol. VII. Part II. 8vo. 1852.

*Lovell, E. B. Esq., M. R. I. (the Editor)* —The Monthly Digest for April, 1852. 8vo.

*North, John, Esq., F.R.S., M.R.I.* —The Anatomy of the Human Gravid Uterus exhibited in figures; by William Hunter. (Published by the Sydenham Society.) fol. 1851.

*Oliveira, B. Esq., F.R.S., M.R.I.*— Human Life, the Phenomena of the Divine Nature and Capacity for Perfection; by *οἱ δύο Ἀδελφοὶ Χειρουργοί*. Part I. The Material Life. 16mo. 1852.

*Phillipps, Sir Thomas, Bart., F.R.S., M.R.I.*—The Cambridgeshire Visitation, by Henry St. George, 1619, from MSS. Phillipps No. 63. Edited by Sir T. P. Bart. fol. 1840.
The Visitation of Middlesex begun in the year 1663, by William Ryley, Esq. Lancaster, and Henry Dethick, Rouge Croix, Marshals and Deputies to Sir Edward Bysshe, Knt. Clariencieux King of Arms. fol. 1820.
Oxfordshire Monumental Inscriptions (from the MSS. of Anthony à Wood, Dr. Hutton, and Mr. Hinton.) fol. 1825.

*Royal Society of London* — Transactions for 1851, Part II. 4to. 1852.
Proceedings, No. 76. and Vol VI. No. 11. 8vo. 1851-2.

*Scoffern, John, M.B., F.S.A. (the Editor)*—The Chemical Record for April, 1852. 4to.

*Statistical Society of London* — Journal, Vol. XV. Part I. 8vo. 1852.

[FOR THE USE OF MEMBERS.]

Royal Institution of Great Britain.

1852.

WEEKLY EVENING MEETING,

Friday, May 7.

W. R. GROVE, Esq. M.A. F.R.S. Vice President, in the Chair.

PROFESSOR EDWARD FORBES, F.R.S.

*On the supposed Analogy between the Life of an Individual and the Duration of a Species.*

IN Natural History and Geology a clear understanding of the relations of Individual, Species, and Genus to Geological Time and Geographical Space is of essential importance. Much, however, of what is generally received concerning these relations will scarcely bear close investigation. Among questionable, though popular notions upon this subject the Lecturer would place the belief that the term of duration of a species is comparable and of the same kind with that of the life of an individual.

The successive phases in the complete existence of an individual are Birth, Youth, Maturity, Decline, and Decay terminating in Death. Whether we regard an individual as a single self-existing organism however produced, or extend it to the series of organisms, combined or independent, all being products of a single ovum, its term of duration can be abbreviated but not prolonged indefinitely, nor can the several phases of its existence be repeated. Conditions may arrest or hasten maturity, or prematurely destroy, but cannot, however favourable, reproduce a second maturity after decline has commenced.

Now, it is believed by many that a species (using the term in the sense of an assemblage of individuals presenting certain constant characters in common, and derived from one original protoplast or stock) passes through a series of phases comparable with those which succeed each other in definite order during the life of a single individual,—that it has its epochs of origin, of maturity, of decline and of extinction, dependent upon the laws of an inherent vitality.

If this notion be true the theory of Geology will be proportionately affected; since in this case the duration of species must be regarded as only influenced, not determined, by the physical conditions among which they are placed;—and, thus, species should characterise epochs or sections of time, independent of all physical changes and modifying influences short of those which are absolutely

destructive. Now, geological epochs, as at present understood, are defined by peculiar assemblages of species, and the amount of change in the organic contents of proximate formations or strata is usually accepted as a measure of the extent of the disturbances that affect them. Yet this latter inference, involving as it does the supposition that the spread and continuity of species in time is dependent upon physical influences, is adverse to the notion of a Life of a Species as stated above.

If we seek for the origin of this notion we shall find that it has two sources, the one direct; the other, indirect. It is not an induction, nor pretended to be, but an hypothesis assumed through apparent analogies. Its first and principal source may be discovered in the comparison suggested by certain necessary phases in the duration of the species with others in the life of an individual, such as each has its commencement, and each has its cessation. Geological research has made known to us that prior to certain points in time certain species did not exist, and that after certain points in time certain species ceased to be. The commencement of a species has been compared with *Birth*, the extinction with *Death*. Again, many species can be shown to have had an epoch of maximum development in time. This has been compared with the maturity of the individual.

Between the birth of an individual and the commencement of a species in the first appearance of its protoplast, the analogy is more apparent than real. We know how the former phenomenon takes place, but we have no knowledge of the latter.

Between the maturity of the individual and the maximum development of a species there is no true analogy, since the latter can easily be proved to be entirely dependent on the combination of favouring conditions, and during the period of duration of a species there may be two or more epochs of great or even equal development, and two or more epochs of decline alternating with epochs of prosperity. The epoch of maximum of a species may also occur during any period in its history short of the first stage. Geological and geographical research equally show that the flourishing of a species is invariably coincident with the presence of favouring and its decline with that of unfavourable conditions. Hence there is no analogy between the single and definite phase of maturity of the individual and the variable and sometimes often repeated epochs of luxuriant development in the duration of a species.

Between the death of the individual and the extinction of a species there is an analogy only when the former event occurs prematurely through the influence of destroying conditions. But in their absence, an individual after its period of vitality has been completed must necessarily die; whereas we have no right to assume that such would be the fate of a species so circumstanced, since in every case where we can either geologically or geographically trace a species to its local or general extinction, we can

connect the fact of its disappearance with the evidences of physical changes.

[The Lecturer illustrated these points by diagrams and special demonstrations, selecting for explanation two local cases, the one marine and the other fresh-water; the former taken from the geological phenomena of Culver cliff and the neighbouring bays in the Isle of Wight, of which a beautiful and original model had been communicated by Captain Ibbetson for the purpose, and the latter from his own recent researches (unpublished) on the succession of organic remains in the Purbeck strata of Dorsetshire, conducted as part of the labours of the Geological Survey of Great Britain.]

The second and more indirect source of the notion of *the life of a species* may be traced in apparent analogies, half-perceived, between the centralization of generic groups in time and space, and the limited duration of both *species* and *individual*. But in this case ideas are compared which are altogether and essentially distinct.

The nature of this distinction is expressed among the following propositions, in which an attempt is made to contrast the respective relations of *individual*, *species*, and *genus* to Geological time and Geographical space.

A. The *individual*, whether we restrict the word to the single organism, however produced — or extend it to the series of organisms, combined or independent, all being products of a single ovum — has but a limited and unique existence in time, which short as it must be, can be shortened by the influence of unfavourable conditions, but which no combination of favouring circumstances can prolong beyond the term of life allotted to it according to its kind.

B. The *species*, whether we restrict the term to assemblages of individuals resembling each other in certain constant characters, or hold, in addition, the hypothesis (warranted, as might be shown from experience and experiment), that between all the members of such an assemblage there is the relationship of family, the relationship of descent, and consequently that they are all the descendants of one first stock or protoplast (how that protoplast appeared is not part of the question) — is like the individual in so much as its relation to *time* are *unique:* once destroyed, it never reappears.

*But*, (and this is the point of the view now advocated) unlike the *individual*, it is continued indefinitely so long as conditions favourable to its diffusion and prosperity — that is to say, *so long as conditions favourable to the production and sustenance of the individual representatives or elements are continued coincidently with its existence.*

[No amount of favouring conditions can recal a species once destroyed — on this conclusion, founded upon all facts hitherto observed in palæontology, the value of the application of Natural History to Geological science mainly depends.]

C. The *genus*, in whatever degree of extension we use the term, so long as we apply it to an assemblage of species intimately related to each other in common and important features of organization, appears distinctly to exhibit the phenomenon of centralization in both *time* and *space*, though with a difference, since it would seem that each *genus* has a *unique centre* or *area of development* in time, but in geographical space may present *more centres than one*.

a. An individual is a positive reality.

b. A species is a relative reality.

c. A genus is an abstraction — an idea — but an idea impressed on nature and not arbitrarily dependent on man's conceptions.

*α*. An individual is *one*.

*β*. A species consists of *many resulting from one*.

*γ*. A genus consists of more or fewer of these *manies resulting from one* linked together not *by a relationship of descent* but *by an affinity dependent on a divine idea*.

And, lastly,

*a*. An individual cannot manifest itself in two places at once; it has no extension in space; its relations are entirely with *time*, but the possible duration of its existence is regulated by the law of its inherent vitality.

*b*. A species has correspondent and exactly analogous relations with time and space,— the duration of its existence as well as its geographical extension is entirely regulated by physical conditions.

*c*. A genus has dissimilar or only partially comparable relations with time and space, and occupies areas in both having only partial relations to physical conditions.

The investigation of these distinctions and relations form the subject of a great chapter in the Philosophy of Natural History. That Philosophy contemplates the laws that regulate the manifestation of life exhibited in organized nature and their dependence upon and connection with the inorganic world and its phenomena. None teaches more emphatically the difficulties with which man's mind must contend when attempting to comprehend the wisdom embodied in the universe, and none holds out a more cheering prospect of future discovery in fresh and unexpected fields of delightful research.

[E. F.]

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In the Library were exhibited: —

Several Cases of Moths, Butterflies, and Beetles, — and various Reptiles, from the Zoological Society.

Specimens of Electro-Plate, in Silver, Bronze, &c. [Exhibited by Messrs. Elkingtons.]

Ino and Bacchus — Little Nell — Psyche, in Cheverton's Machine Sculpture. [Exhibited by W. T. Copeland, Esq.]

Partridge and Woodcock, worked in Leather, in imitation of Wood-Carving, by Mr. W. Sanders.

Portraits of John Dalrymple, Esq., F.R.S. and of Dr. Holland, F.R.S., by J. Z. Bell, Esq.

Mr. C. Varley exhibited several interesting objects by the Microscope.

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## WEEKLY EVENING MEETING,

Friday, May 14.

Sir Charles Fellows, Vice-President, in the Chair.

The Rev. Edwin Sidney,

*On the Rise of the Sap in the Spring.*

After a few prefatory observations, the speaker divided the subject into four parts which he proposed to consider in order. 1. A short description of certain physical phenomena to be regarded as preparatory. 2. Their application to the known organism of vegetable structures. 3. The circumstances under which these organisms will be called into that activity which may be regarded as the proximate cause of the rise of the sap in the spring. 4. The diffusion of the sap through the plant. The inquiry was limited of course to plants of our own climate.

1. In directing attention to the first part of the subject, it was observed that vitality must not be disregarded. The *most* chemical and physical forces fail to explain all. Vital force is mysterious, it is true, but so are all forces. If there were not a living formative force superadded above dead physical forces, all the varieties of organized substances could not originate as they do from a simple vesicle. The phenomena now to be considered were those of capillarity and endosmosis. The former is greatly affected by temperature, and the imbibition due to it differs much in different liquids and solutions. Endosmosis is known as the phenomenon of the mixture of two liquids of unequal density through a membrane, accompanied by a change of volume. It is called endosmosis when the volume increases, exosmosis when it diminishes. It is generally, but not always, found that when the heavier liquid is above the lighter, mixture is accelerated by the interposition of the membrane. Other things equal, the force of the current varies as the excess of the density of the interior liquid proportional to water. A current with a pressure of several

atmospheres is producible by albumen.—There are those who regard capillarity and endosmosis as modifications of the same attractive force existing beween solids and liquids. But different conditions are required. Capillarity is a statical effect, and so differs from the double current of endosmosis and exosmosis.

2. In applying these phenomena to the vegetable organism, it was noticed that plants have no particular vessels carrying nutrient fluids, but their open tubular structure is a condition favorable to capillarity. Plants have ducts, and so called vessels; but the latter, except at certain times, contain air, and are not in connection with the stomata. The fulness of the ducts is due to capillarity. The structure of plants is favourable to endosmosis: the life of a cell involves an act of it. It is promoted by the thickening of the cell contents due to evaporation and other causes, and new materials are furnished by the lighter fluids surrounding the cells. The fine extremities of the roots are in the condition of the interposed membrane, and thus we have conditions of endosmosis — a vessel with organic sides, an exterior liquid capable of being imbibed by this tissue, and an internal liquid also capable of being imbibed by this tissue, of mixing with the exterior liquid, and permeating the tissues. The force detected at the root appears throughout the system; and it is obvious that the contiguity of the cells to each other is promotive of an interchange of contents by endosmosis. Juices may be collected from plants by boring; and while the sap movements are active, the higher the bore the thicker the juice: and albumen, the fluid most forcible in endosmosis, is closely connected with proteine compounds found in developing cells. The more active the development, the denser the fluid; insoluble starch is found in the cells when store is required, and when nutrition is active it is changed into gum, dextrine, and sugar. The nature of the cells, vessels, &c. spoken of was illustrated by diagrams.

3. In proceeding to the third point it was observed that the movements under present consideration were not rotations or mere movements of cell contents, nor could they be regarded as having any analogy with the circulation of animal fluids through arteries and veins. They are the movements by which nutrient fluids are conveyed to the organs of development. To aid in this conveyance two agencies appear, endosmosis and capillarity. If at any one time all the cells of a tissue contain a fluid of equal density, endosmosis takes place in those which come into immediate proximity to water, which dilutes their fluids and sets up the conditions of endosmosis between them and the next cells. Where evaporation is most active, there is the greatest concentration of sap; therefore the stream is towards the green parts and buds. The rise of the sap, generally, may be regarded as effected by the increased density of the fluids as they approach the seat of the evaporating process. Curious experiments by Mr. Lawes, which were detailed by the aid of drawings,

taught that for every grain of solid matter fixed in the plants tried when healthy, two hundred grains of water passed through by evaporation. Capillarity due to the ducts must also be taken into account in the rise of the sap. As regarded its rise in the spring, when the vigorous movement so well known takes place, a distinct explanation could be given. Here several experiments of Hales were mentioned as examples of ingenious method, but the true inferences could not be made at that time for want of knowledge. The quiescence in winter is due to the way in which evaporating surfaces are closed, and even sealed up, so that capillarity, which does not take place in sealed tubes, cannot act. The cells of buds are then filled with thin fluids. As spring advances, the thickening takes place under the influences of heat and moisture. Now we have the conditions of strong endosmosis. Development takes place, next comes evaporation, and capillarity acts. These two forces are therefore brought into full play, and the whole cellular chain is put into action from root to bud. In monocotyledons the upward course is through the most newly formed tissues, which are in the interior of the stem. In dicotyledons it passes along the last formed tissues of the wood, forming a pabulum for the cambium. All young tissues are permeable to the absorbed fluid, and whatever is formed of a soluble nature in one part of the plant, is conveyable to another. Thus a compound formed in the leaf may find its way to the stem and even the roots, which latter is most likely to take place in the autumn, and indeed goes to explain what is called root-action at that season.

4. The last point was the diffusion of the sap. This subject is at present by no means in a settled condition by reason of differences of opinion, and the influence which the long received views of a regular descent of sap, after elaboration in the leaves, still has upon many persons. There is, however, no proof whatever of the formation of ligneous tissues in the leaves, and the old theories of Duhamel and others are not to be maintained. Still it is not to be forgotten that it has already been shewn that compounds formed in the leaves may pass downwards, therefore the possibility of a descending sap remains, while there is no general demonstration of the fact. Ascent and diffusion may be regarded as sufficient to account for all the phenomena of growth. The old arguments in favour of a descending liber current in exogens, such as ringing the bark and grafting, are capable of other interpretations than those which they have received. A remarkable specimen of stock and graft was shewn, to prove that their growths were perfectly distinct, though nourished by a common food. If there were a descending bark sap, could this be so? The fact is, the new annual rings are formed out of a cell development of the cambium. To shew that the proper expression for the distribution of the sap is *diffusion*, an account was given, and drawings shewn, of some very remarkable experiments on a horse-chesnut, at Glassnevin near Dublin. They tended to prove that when the sap-flow from cell to cell was interrupted by the al-

burnum and cambium being cut across, it at once diverged laterally. There was nothing to indicate a vertical descent, but, on the contrary the current by endosmose took the directions indicated by circumstances. When also we consider the phenomena exhibited by cuttings of plants turned upside downwards, they indicate diffusion, according to the physical laws which have been considered, rather than such movements as have been so long attributed to currents of sap. If these facts be coupled with the proofs that may be given that the upward and downward channels so often taken for granted by vegetable physiologists have no ostensible existence, it must be allowed that the old theories, however fascinating, must give way, and the movements of the nutrient fluids be interpreted on sound principles. We shall be safe in speaking of the diffusion of these fluids as taking place according to the laws which have been demonstrated, and which must be considered as prevailing, not only as we know they do, in amorphous cellular masses, but in regularly organized structures.

The speaker concluded by apologizing for bringing this subject forward before such an audience, but his design was to excite to inquiry into the phenomena alluded to as amongst the most interesting that could occupy the attention. In the course of the evening there were also cited some experiments by the speaker on parts of plants in active growth with ozonometric tests, which manifested such actions as would consist with the idea that either ozone, or oxygen tending to act like ozone, was in some manner present at the places tested. If so, these phenomena might tend to throw new and important light on the chemistry of vegetable life.

[E. S.]

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In the Library were exhibited:—

Casts of the Venus de Medicis, Venus of Melos, Apollo Belvedere, Laocoon, Dying Gladiator, Head of Jupiter, (reduced by Machinery). [Exhibited by R. Westmacott, Esq.]

The Theseus and Ilyssus, — Machine Sculpture, by Mr. Cheverton.

Bourdon's Metallic Barometer and Steam-Gauge, with enlarged models. [Exhibited by Mr. Dewrance.]

Model of Appold's Self-regulating Friction-break,—Labour-Machine for Prisons. [Exhibited by J. G. Appold, Esq., M.R.I.]

A New Instrument for Drawing Ellipses, by Dr. Roxburgh, M.R.I.

Crystals of Sulphate of Quinidin; and Specimens of Cast Iron, Ancient and Modern. [Exhibited by T. N. R. Morson, Esq., M.R.I.]

Photograph Portrait of Biot by M. Regnault. [Exhibited by Mr. Faraday.]

Portraits of Sir B. C. Brodie and the Rev. T. Eagles, and Sketch of a Poor Irish Girl, by J. Z. Bell, Esq.

15 Ammonites from the Secondary Formations, Exhibited by Mr. Tennant; and an Engraving of the "Ammonites Heterophyllus," presented by him to the Royal Institution Library.

Mr. Varley showed by the Microscope the beating of the heart in the Monoculi and Wheel-animalcules.

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## WEEKLY EVENING MEETING,

Friday, May 21.

W. R. Grove, Esq., M.A., F.R.S., Vice-President, in the Chair.

B. C. Brodie, Esq.

*On the Allotropic Changes of Certain Elements.*

The earliest conception of the nature of a chemical substance was limited to the knowledge of the ultimate or elemental particles into which it could be broken up. To this after a time was added that of the proportion in which these elements were combined. But this too proved inadequate to explain the chemical differences of bodies, especially their dynamic differences, that is, the different modes of change of which they are susceptible — why for example, from certain bodies containing many atoms of hydrogen, one of these atoms can readily be removed and replaced by a metal, while no skill has yet effected a similar exchange with a second. The progress of discovery, moreover, established beyond a doubt the existence of a class of bodies consisting of the same elements, combined in the very same proportions, which yet differed in their chemical and physical properties. To meet these and other difficulties, gradually arose an idea new to chemical science, the idea of structure or *chemical form*, in the elaboration of which, chemists of late years have been principally engaged. The way in which this conception has been applied to explain the relation of isomeric bodies may be seen by the following illustration. Representing water as $\begin{matrix} H \\ H \end{matrix} O$, alcohol is represented as $\begin{matrix} C_2\,H_5 \\ H \end{matrix} O = C_2\ H_6\ O$, and methylic ether as $\begin{matrix} C_2\ H_3 \\ C_2\ H_3 \end{matrix} O. = C_2\ H_6\ O$. This last substance is identical with alcohol in its elemental constitution, but differs from it in its

chemical reactions. This difference is expressed by assuming that the hydro-carbon is differently distributed in the two substances. Looking at the above formulæ, it will be perceived that the conversion of the one substance into the other would be effected by the transference of hydro-carbon from one to the other part of the system. The change in this case has not yet been effected; but in certain other instances we are enabled to effect very analogous transformations, and to recombine the particles in the interior, as it were, of the body itself.

One or two instances were shown of this isomeric metamorphosis, which were so selected as to illustrate the modes by which it could be effected. For example — styrol, (an oil procured by the distillation with water of the liquid storax), by the application of heat, is converted without either the addition or the loss of any chemical substance into a transparent solid, in its ultimate constitution identical with the oil. The formula of the oil is $C_8\ H_8$, that of the solid according to Blyth and Hofmann, who first made it a subject of investigation, $C_7\ H_7$.

In certain cases these changes may be brought about by a chemical action very analogous to that of fermentation, by which sugar is converted without alteration of weight into carbonic acid and alcohol. There is a body called aldehyde, $C_2\ H_4\ O$, a very volatile substance boiling almost with the warmth of the hand, and the vapour of which is about $1\frac{1}{2}$ times as heavy as air. By the addition of one drop of sulphuric acid it is converted into a body which boils at a higher temperature than water, and the vapour of which is $4\frac{1}{2}$ times as heavy as air. Our knowledge is too imperfect to state the precise mode in which the elements are re-arranged, but from the density of the vapour we infer that the molecule of the transformed aldehyde contains three times the number of atoms of the original body and is $C_6\ H_{12}\ O_3$. Oil of turpentine is in a most remarkable degree susceptible of these metamorphoses. By the action of sulphuric acid it is converted into oils, isomeric with it, but each differing from it in some one or more properties. Great heat is evolved during the change, due doubtless to the chemical combination which is taking place. In certain cases, as, for example, the formation of paracyanogen by the decomposition of cyanide of silver, this heat is so great as to cause the vivid ignition of the substance.

Acquaintance with these facts is necessary to view in their scientific connexion certain phænomena of the elemental bodies which go under the name of *allotropy*, and which are to them, precisely what isomeric phænomena are to compound substances. This allotropy has been observed in the case of many elements, carbon, boron, silicon, selenium, sulphur, phosphorus, arsenic, and possibly oxygen—from these sulphur and phosphorus were selected as presenting points of peculiar interest.

At a few degrees above the boiling point of water, Sulphur

melts to a transparent yellow fluid; at about 160° C. it changes in appearance, becoming red, and between 220° and 250° C. it becomes deep red and viscid. Heated beyond this point it again becomes liquid, and just before it boils appears as a deep black fluid. These changes in the sulphur have been connected with certain thermic phænomena, which leave no doubt but that they are truly transitions from one allotropic form to another. During cooling, sulphur passes through the same changes, but in an inverse order; and it has been observed that the sulphur does not cool by regular gradation, but that at certain points its temperature is stationary, or falls much slower than at other points; this can only be explained by assuming a developement of heat from the sulphur itself, which compensates for that which it loses; and this developement of heat takes place just about the points of transition from one state to another. By cooling suddenly the viscid sulphur, it may be retained for a long time in the form of a transparent elastic substance, which ultimately solidifies to a sulphur differing in many respects from the ordinary modification of the body, especially in being in great measure insoluble in bisulphide of carbon.—An experiment was shewn of the reconversion of this peculiar sulphur into the viscid form; this can be effected without melting the body by a proper regulation of the temperature.

It had been long known that Phosphorus exposed to sun-light assumed a red colour. Berzelius suspected this to be an allotropic modification of the element; and the experiments of Schrötter, who produced the same body by the action of heat, have established this view and enable us to procure this phosphorus in large quantities. In its chemical properties, as well as in appearance, this red phosphorus is entirely different from the ordinary modification.

The change thus produced by heat can also be effected by chemical agency. By the action of iodine ordinary phosphorus can be converted in large quantities into the allotropic modification. This can be done by projecting iodine into phosphorus melted under strong hydrochloric acid, or into phosphorus simply melted in a tube, and subsequently heating the substance. The iodine is employed in very small quantities. It first dissolves in the liquid phosphorus; at a certain point as the temperature is raised a violent evolution of heat takes place, which causes a kind of explosion in the substance, and the mass of the phosphorus passes at this moment into the other condition. A small quantity of iodine will in this manner convert (if sufficient time be allowed) an absolutely unlimited quantity of phosphorus.*

On a former occasion certain experiments were shown as evidence that the formation of oxygen, and indeed of other elements, was a

* The theory of this action and the detailed experiments are given in a Paper on the action of Iodine upon Phosphorus, read by the Author before the Chemical Society on the 21st of June.

chemical combination of particles of the same nature as the formation of a compound substance, and that the two classes of bodies had a similar molecular constitution.* By the phænomena of allotropy, other analogies are brought out between them, which lead to a similar belief. The similarity is so great between the facts in the two cases, — they are produced by the same means, by the alteration of temperature and by chemical action, — they are attended with the same evolution of heat, — that it is reasonable to refer them to the same cause. In the case of the compound substance we have the most direct evidence that the allotropic conversion is the re-combination of the particles of the substance and the transition from one chemical type to another. The inference is that the change in the case of the elements is of the same nature, and that phosphorus and sulphur are molecular groups capable of this re-arrangement and re-distribution.

[B. C. B.]

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In the Library were exhibited: —

Sulphur in its Native, Crude, Refined, Commercial, and Pharmaceutical Forms. [Exhibited by Mr. S. Highley, jun.]

Cardinal Wiseman, from the Bust by Mr. C. Moore, in Machine Sculpture, by Mr. Cheverton.

Various Groups in Parian. [Exhibited by Mr. Addey.]

Ancient Egyptian Ear ornaments; — Etruscan ear-rings, and sarcophagus; — Roman bulla, fibula, spoons, ear-rings; — Saxon clasps, fibula, and boss of shield; — Celtic gold armilla, and fibula; bronze armilla; silver armilla; Saxon portions of the Mancus, Cuerdale; — Ancient carvings in bone. [Exhibited by W. Chaffers, Esq., F.S.A.]

Testimonial (in Silver) to the 60th Rifles, by Major Moore. [Exhibited by Messrs. Hunt and Roskell.]

Portrait of Lady Bryant, by J. Z. Bell, Esq.

Minerals, and Sulphur Casts from R. I. Museum.

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* See on this subject the Author's Paper in the Philosophical Transactions, 1850, " on the Condition of certain Elements at the moment of Chemical Change."

## WEEKLY EVENING MEETING,

Friday, May 28.

William Pole, Esq., M.A., F.R.S., Treasurer and Vice-President, in the Chair.

John Percy, M.D., F.R.S.,

LECTURER ON METALLURGY AT THE GOVERNMENT SCHOOL OF MINES, &c.

### *On the Modes of Extracting Gold from its Ores.*

Dr. Percy began by stating that it was not his intention to touch upon any of those very interesting and important questions,—the distribution of Gold upon the earth's surface; the geological features of the regions which are believed to be indicative, not to say characteristic, of its presence; or the probable economical effect which the present unexampled supply may be expected to produce. To treat these subjects satisfactorily would require very much more time than that allotted to him on the present occasion. He should, therefore, direct special attention to certain points which he had reason to believe to be at the present time the most interesting.

After a brief review of the physical and chemical properties of gold, of special importance in the consideration of the subject, the Lecture was treated as follows:—

*Modes of occurrence of Gold in nature.*—Gold almost always occurs in nature in the metallic state; not pure, but alloyed with silver in various proportions and with the occasional addition of small quantities of iron and copper. A table* was presented, shewing the composition of native gold from various parts of the world. The presence of silver is constant with one or two rare exceptions; and its proportion varies not only in native gold from different auriferous districts, but even in specimens from the same locality. In Hungary gold is met with in combination with Tellurium. Native gold occurs crystallized and amorphous in small grains of greater or less size, in lamina, and sometimes in masses of the weight of many pounds.

*Matters associated with native Gold.*—These are various, such as quartz, either massive, or in a state of fine division as siliceous sand,—clay,—frequently certain kinds of iron pyrites,—rarely galena, &c. It seems doubtful whether in every instance the gold occurring in association with iron pyrites is wholly in the metallic state.—Spe-

[* The Members are referred, for many of the tables and diagrams illustrating this discourse, to Dr. Percy's Lecture, forming one of "The Lectures on Gold, delivered at the Museum of Practical Geology," published by Bogue, price 2*s.* 6*d.*]

cimens of gold were exhibited which had been extracted from pyrites from Wicklow in Ireland, Alston in Cumberland, and California. From historical records it would appear that gold has occasionally been found in different parts of the United Kingdom, but never in quantities to justify the slightest comparison with the recently discovered gold fields. In 1796, great excitement was caused by the discovery of gold in Wicklow, and about £10,000 worth of metal is said to have been obtained, but at a cost which did not cover the expences of extraction, notwithstanding that one lump was obtained weighing 22 ounces! It is very important, that at the present time, when so much excitement prevails respecting the newly explored gold regions, the public should not be misled by the notion that the extraction of gold will in every instance be profitable.

*The extraction of Gold from auriferous sand or alluvium.*—The method of washing by the bowl was described, and some different forms of bowl shewn. The principle of separating gold by washing depends upon its very high specific gravity as compared with that of the associated matter. The process carried on in the Ural was described in detail, and illustrated by diagrams. The average proportions of gold separated is little more than half an ounce to five tons. From 1819 in Siberia, and in the Altai from 1830 to the beginning of 1850, 774,920 lbs. (avoirdupois) of gold were obtained, of the value of about £46,495,200 sterling (Zerrener). The weight of matter removed by washing in the extraction of that amount of gold was (taking the average of half an ounce to five tons) 297,569,280,006 pounds, or 128,379,142 tons.

*Stamping, washing, and amalgamation.*—When gold is diffused through masses of quartz, as in the auriferous quartz veins of California, the mass must be reduced by stamps to a fine state of division. The product is washed in various ways; and the fine portions of gold, which might otherwise be carried away, are retained by mercury in an apparatus called the *amalgamation mill.* The method in practice at Schemnitz for this purpose was minutely described, and illustrated by diagrams, without which it would be difficult to render the processes intelligible.

*Smelting of Gold ores, or the extraction of the metal in the furnace.* The quartz must be reduced to a state of fine division and mixed with a substance which at a high temperature will combine with it and convert it into a fusible glass or slag. Such a substance is lime in certain proportions, or oxide of iron, or still better a mixture of the two. But as the gold exists only in very small proportion as compared with its matrix of quartz, it is necessary to introduce into the furnace lead, which may serve the purpose of dissolving and collecting the gold. By thus forming an alloy of gold and lead, and greatly increasing the bulk of the metal, which will subside to the bed of the furnace below the slag, the loss of gold will comparatively be prevented. In the event of employing oxide of iron as an agent to effect the fusion of the quartz, it would

obviously be desirable, when practicable, to obtain it by roasting with access of air on auriferous iron pyrites, such as the Californian.— The result of several experiments on the smelting of auriferous quartz were placed before the audience. The gold is separated from the lead by well known and ancient processes of cupellation. In the smelting of what is termed "Sweep," or the dust obtained by the sweeping of the shops of silversmiths and jewellers, the same principle is adopted. Lead is added, either in the metallic state, or in a state of combination, from which it may be evolved in the metallic state in the furnace, as in the case with certain lead slags. The part which mercury plays at the ordinary temperature in the amalgamation mills is performed by lead at a high temperature in the furnace. Anossow, a Russian engineer, is reported to have made successful experiments in the smelting of the gold-sand of the Ural by substituting cast iron for lead, and subsequently dissolving out the iron from the gold by sulphuric acid. He asserts that by this means he procured a very much larger quantity of gold than could have been separated by the most careful washing. His results, however, have not been received as correct. The results of experiments on the use of cast iron as a vehicle to collect the gold, were placed before the audience. By simply melting the cast iron in contact with lead, the greater part, if not the whole of the gold, appeared to be extracted from the iron with which it had been alloyed.

Although no positive opinion was expressed respecting the desirableness, or otherwise, of smelting the auriferous quartz of California, yet it was suggested, that in the event of the smelting process being adopted, it would, probably, for various reasons be found advantageous to smelt the quartz in conjunction with some of the South American silver ores, many of which contain gold.

The smelting of auriferous pyrites was next described. The pyrites is first roasted, by which process oxide of iron is formed. The roasted ore is smelted in a blast furnace with unroasted ore. A slag is obtained, and below sulphide of iron (or, as it is termed, a "*matte*,") containing the gold from the two portions of ore. This "*matte*" may be roasted, and again smelted with another portion of unroasted ore. A slag and "*matte*" are again obtained, and the latter will contain the gold from the three portions of ore. The gold may thus be concentrated, and ultimately extracted from the "*matte*" by smelting with lead. Many details were necessarily given which do not appear in this general notice of the lecture.

*The treatment of certain auriferous ores by Chlorine.*—Chlorine dissolved in water has been employed in extracting gold from a poor auriferous arsenical pyrites at Riechenstein. The ore is roasted, and the products treated with chlorine water. The gold is dissolved as chloride, and precipitated from its solution by sulphuretted hydrogen.

The sulphide of gold is converted into metal by the agency of heat alone.— A Council Medal was awarded for this process at the Great Exhibition of last year. In the first number of the Philosophical Magazine for 1848 will be found a series of experiments on this subject made by the Lecturer in 1847.

*Melting of the Gold dust.*—The gold obtained in grains (pepites) by washing, is melted in black lead crucibles with borax. The slag containing the foreign matter is skimmed off. A little corrosive sublimate is then, in particular cases, dropped in, after which the metal is cast into ingots. The use of corrosive sublimate is of ancient date. Some metallurgists believe its addition to be useless; but it is still occasionally employed by gold-melters of great experience.

*Parting or separation of the Silver.*—This is effected either by nitric or sulphuric acid. Gold must be alloyed with from $2\frac{1}{2}$ to 3 times its weight of silver to allow of the removal of the latter by the agency of either of those acids. The method of parting by nitric acid is well known. The process was briefly described. The silver dissolved out from the gold is now generally precipitated from its solution in nitric acid as chloride, by the addition of common salt. The chloride is washed and reduced to the metallic state by zinc.— Dr. Percy had intended to have given the results of careful experiments on the large scale, made by himself on the use of cast iron vessels in parting by sulphuric acid. The use of cast iron, for this purpose, was long ago proposed by a Frenchman at Marseilles. In the experiments just referred to, several thousands of ounces of silver were operated on. No description has yet been published, so far as he is aware, giving all the practical details necessary to the successful application of iron vessels for parting. The shortness of the time prevented the fulfilment of the intention abovementioned.

"In conclusion," said Dr. Percy, "permit me to offer a few observations in connection with the subject which I have ventured to submit to the Members of the Royal Institution. That subject is essentially what is termed *practical*. Yet in every process which we have examined, the principles of science are involved. The metallurgic arts present a varied and beautiful field for investigation, and merit greater attention from chemists than they have yet received, at least in this country. The reactions which take place in many metallurgical operations require for their elucidation the highest science, and have only to be known to be duly appreciated. This evening I may speak freely of the attractions of metallurgy to the chemist, who is intent upon the investigation of the glorious truths of science for their own sake; but if I had to address Manufacturers upon the advantage of the applications of science to metallurgy I should be under the necessity of employing the only argument which will avail with them,—that of direct and positive advantage.

"We have seen, that although Gold may be present only in very

small quantity, it may yet by skilful manipulation be extracted with advantage; and in these days of gold-mining adventure, it is to be feared, that many may be led by this consideration to believe that wherever gold is found, there is a favourable field for mining enterprize. But it must not be forgotten, that it is not merely a question of the *occurrence of gold* in any given district, but whether it is present in sufficient quantity to admit of profitable extraction. If it were necessary,— as I am credibly informed it would be in one locality,— to expend a sovereign in order to extract sixteen shillings' worth of gold, dividends would be expected in vain.

"The consumption of gold in the *Arts* is an interesting subject of inquiry. A very large amount of that which is thus applied is irrecoverably lost,— as, for instance, the gold employed for gilding with gold leaf, and that used in ornamenting china. Some idea of the extent of this loss may be formed, from the fact that one gold-beater will consume many thousand pounds' worth of gold annually, and there is one manufacturer of china who consumes annually not less than £2000 worth of gold. There is also a large consumption of gold in what is called the gilt-toy manufacture. It seems probable that if the metal should become much more abundant, its applications in the Arts would be proportionately extended.

"Gold after all does not constitute the true riches of a nation. On account of its hitherto comparatively rare occurrence and gradual supply, it has been well selected as the conventional representative of wealth. It is a very beautiful metal and is well adapted to the various purposes of ornament to which it is applied; but in respect to *intrinsic* excellence it will not compare with *iron*. A golden needle would be a poor substitute for one of polished steel, and no ordinary skill would be required to operate upon a tender joint with a golden knife. Iron-stone and coal, with conditions favourable to their being worked, are more to be desired than the treasures of an El Dorado; and probably the most important, though distant result of the discovery of gold in California and Australia, will be that of developing the natural resources of those great countries, by attracting the tide of emigration to their shores."

[J. P.]

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In the Library were exhibited: —

Four Specimens of Gold in Quartz from Ballard Diggins, near Port Philip, Australia. [Exhibited by R. Brooks, Esq.]

Baillie's Patent Volute Springs, with Model of Railway Carriage. [Exhibited by Mr. Howard.]

Specimens of Silicious Conglomerate from Hertfordshire, and of Krokidolite. [Exhibited by Mr. Tennant.]

Manufactures in Imitation-Ivory and Protean Stone, by Mr. Cheverton.

A Collection of Shells arranged for the Study of Conchology; and Specimens of Cinnamic Acid and Tantalite. [Exhibited by T. N. R. Morson, Esq., M.R.I.]

Illustrations of Endosmosis, from Royal Institution Laboratory.

Design for the Chemical Society's Seal, by J. Bonomi, Esq. and Impressions from the Seal, engraved by Mr. G. Barclay.

Map of Gold Country, Bathurst, Australia. [Exhibited by Mr. Lloyd.]

Model of "the Martyrs' Memorial," Oxford, by Mr. Flack.

Portrait of a Lady, painted in Pastel on Vellum, by Alexander Blaikley, Esq.

Portraits of Sir James Duke, Dr. Chambers, and Mrs. Blake, by J. Z. Bell, Esq.

Three Caps made of Needlework, worn by the Mopilas, or Muhammedans of the Malabar Coast; Chinese Painting on Glass; Specimen of Tea prepared for the use of the Emperor of China; the Jooee or Talisman of good Omen placed by the Chinese in their chief apartments; Chinese Lady's Shoe and Metallic Mirror. Various Articles of Burmese Costume. Maliva and Kandeish Opium and the Opium Pipe of the Chinese. [Exhibited by the Royal Asiatic Society.]

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## WEEKLY EVENING MEETING,

Friday, June 4.

Sir Charles Fellows, Vice-President, in the Chair.

John Scott Russell, Esq., F.R.S.

*On English Ships and American Clippers.* (Second Notice.)

Mr. Scott Russell commenced his discourse with the following remarks:

"When I had the pleasure a month or two ago of stating a few facts, and hazarding some opinions, regarding the present state of knowledge, and the actual progress of practice in the construction of ships, I confined my remarks, which were necessarily few and imperfect, to American Ships and Yachts, comparing them especially with our own. I selected the Americans, because I believed them to be more advanced in the Arts of Navigation and Naval Construction than any other nation; and because it may be regretted that they are so, inasmuch as *we* were not long ago in the place they now occupy: and secondly, because I believed it to be entirely owing to our own adherence to prejudices, and to an antiquated system established by bad legislative enactments, that we have been left behind, with larger

capital, longer experience, more extensive colonial trade, and larger commercial relations with every nation of the world.

" It is impossible to escape from the conclusion, that, if we are behind the Americans the fault is entirely ours, and the superiority must be attributed either to the greater knowledge, intelligence, adroitness, or ability of the Americans, or to ignorance, prejudice, or supineness on our own part.

" If I then succeeded in satisfying you, that it would not be wise any longer to assert our hereditary superiority by *words* merely; if I led you to do more justice than we have hitherto done to our younger brother over the water; if I led you to believe it was just possible that our younger brother, with some faults, was less prejudiced and more active than we have hitherto been willing to give him credit for, and that it is just possible that Old Britannia, rich, indolent, and shutting her eyes, might have inadvertently let the sceptre of the waves drop from her fingers; then I accomplished all I hoped for. To be well assured that we are *not first* is, I hope, enough with Englishmen to secure that we *shall be.*

" To-night I shall endeavour to go more fully into the question, *How?* How shall we now, rapidly and surely, make progress in navigation and naval construction?

" If I may venture to state any single source to which I should look for the advancement of naval construction in this country, I should say it was from the general increase of knowledge of the true principles and theory of ship-building among all the classes of society who are connected with the naval and shipping interest of this country.

" This may appear to be a common-place remark; and it may sound like a truism, to say that we should all do better if we knew better. But the diffusion of knowledge of the kind I mean, among the classes I refer to, is really more practically valuable than does superficially appear. In this country there is a vast number of persons, and a great variety of interests, concerned in the construction of every ship.— First, there is the Legislature who make Acts of Parliament for ship-building; —Then there is "Lloyd's" who make rules and regulations for ship-building, and who give the certain rank and classification according to their own notions of what a ship should be; —Then there are the Insurance Brokers who insure a ship at a larger or a smaller premium, according to their rules for the security of a ship and the property she contains; —Then there come the Proprietors of Harbours and Docks who charge tonnage-dues according to certain registers and laws; and Boards who regulate pilotage and make other nautical laws according to their own notions and principles; —Next comes the Ship-Owner or Merchant, who orders the ship from the ship-builder and holds the purse-strings; and he too, who never sailed a ship in his life, he too has his notions right or wrong, not only of what his ship ought to be, but of how he ought to have her constructed: he virtually dictates to the

Builder the radical points of construction, which compel him to make a bad ship, or at least deprive him of the elements of a good one:— Then comes a more important man, even than the ship-builder or the owner,—the Captain who is to sail the new ship, who has sailed the preceding ship, who may have no notion how the ship is formed, and yet may have prejudices as strong, and notions as obstinate, as if his will were a law of nature, and his notions truths in hydraulics; Then there is the Lumper who stows your ship by contract, and your Mast-maker who puts in his spars, and the Sail-cutter who cuts your sails, and the Rigger who places ropes and blocks; all done by each contractor, and by every one under him according to the rules of his trade. Among all these gentlemen, let me ask you, if they are ignorant and prejudiced, what is to be expected from the poor ship-builder?—and the poor ship?—To improve British navigation we must improve the state of knowledge of all these classes, and by that means alone can extensive improvement take place in the Naval constructions of England."

The Lecturer then explained, and illustrated by diagrams, the various points in the construction of a ship which give her peculiar qualities, dividing the examination of a ship into three categories:

1st, The Geometry of Naval Construction, viz.:—
The Midship Section.
The Body Plan.
The Sheer Plan.
The Water Lines.
The Ribband Lines.
The Buttock Lines.

2nd, The Mechanical Qualities of Ships:
Weight.
Displacement.
Stability—Statical and Dynamical.
Easiness in Rolling and Pitching.
Dryness.
Weatherliness.
Handiness in Working.

3rd, Equipment and Stowage of Ships, as affecting their qualities:
Trim.
Stowage.
Centre of Weight.
Centre of Oscillation.
Sails.
Masts.
Number of Men.
Economy of Working.

In regard to these three classes of elements, it was shewn that all must be combined with a perfect understanding of the effect of each

on the others, to make a good performance; otherwise, by bad equipment, bad stowage, or ignorant handling, a good plan might result in a bad ship; or a good ship, stowed and equipped without knowledge of her form and qualities, might be rendered in practice a sorry performer. The elevation of all classes connected with shipping, in general intelligence on all the points that approach a ship's performance, is the only sure means of advancing our naval position among other nations.

[J. S. R.]

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In the Library were exhibited: —

Dr. Junod's Exhausting Apparatus. [Exhibited by Dr. Junod.]

Casts of Eggs of Æpyornis Maximus, Madagascar; Birds mounted by Mr. A. D. Bartlett.

Starling and Blackbird, — Imitation (in Leather) of Wood Carving, by Mr. Sanders.

Flexible Chain cast in one Piece by Messrs. Midworth, Newark. [Exhibited by Mr. Duer.]

Chinese, Burmese, and Malay Swords, — Chinese Tea-pot — Old Dutch carving, "Adam and Eve expelled from Paradise." [Exhibited by Dr. W. V. Pettigrew, M.R.I.]

Vases in Parian China, — Marble Cross inlaid, — Stag and Buffalo in Cast-iron, — Ortheroceratite and Section — Cast of Helmet from one in Silver in the Paris Museum. [Exhibited by Mr. Tennant.]

A Daguerrotype Portrait of Sir John Herschell. [Exhibited by Major Jervis, M.R.I.]

Roman Bronze Antiquities. [Exhibited by W. Chaffers, Esq., F.S.A.]

Ibbetson's Geometric Chuck for producing Bi-cycloid Curves. [Exhibited by Mr. Perigal.]

Portrait of Erasmus Wilson, Esq., by Miss Jane C. Bell.

Mr. C. Varley exhibited various Animalcules, by the Microscope.

## GENERAL MONTHLY MEETING,

Monday, June 7.

William Pole, Esq., M.A., F.R.S., Treasurer and Vice-President, in the Chair.

Wentworth William Buller, Esq.
A. S. Oliver Massey, Esq.
Richard Jennings, Esq.

were *admitted* Members of the Royal Institution.

Charles Blakely Brown, M.D.
Robert M'Calmont, Esq.
John Peter Fearon, Esq.
Miss Harriet Moore.
Edward M. Foxhall, Esq.
David Oldfield, Esq.

were duly *elected* Members of the Royal Institution.

A Letter was read from W. T. Brande, Esq. expressing his deep sense of the distinction conferred on him by his election as Honorary Professor of Chemistry in the Royal Institution.

The following Presents were announced; and the thanks of the Members returned for the same:—

From

*Anderson, W. J. Esq., F. R. C. S., M. R. I. (the Author)*—The Symptoms and Treatment of the Diseases of Pregnancy. 12mo. 1852.

*Alessandro, Sella, da Torino (the Author)*—Una Visita all' Abendberg, 10 Sett$^e$. 1850. 8vo.

*Asiatic Society of Bengal*—Journal, No. 225. 8vo. 1852.

*Astronomical Society (Royal)*—Monthly Notices, Vol. XII. No. 5. 8vo. 1852.

*Bell, Jacob, Esq. (the Editor)*—The Pharmaceutical Journal for May, 1852. 8vo.

*British Architects (Royal Institute of)*—Proceedings, May, 1852. 4to.

*Civil Engineers (Institution of)*—Proceedings, May, 1852. 8vo.

*D. C. L. (the Author)*—Letters on Church Matters. Vol. III. 8vo. 1852.

*East India Company, The Hon.*—Meteorological Observations made at the Magnetical Observatory, Singapore, by Capt. C. M. Elliott, in 1841-45. 4to. 1850.

*Editor*—The Athenæum for April, 1852. 4to.
The Medical Circular for May, 1852. 4to.

*Esdaile, James, M.D. (the Author)*—The Introduction of Mesmerism as an Anæsthetic and Curative Agent into the Hospitals of India. 8vo. 1852.

*Faraday, Professor*—Geschichtliche Darstellung des Galvanismus von O. E. J. Seyffer, Ph. D. 8vo. 1848.
Traité des Phénomènes Electro-Physiologiques des Animaux, par C. Matteucci suivi d'Etudes Anatomiques sur le Système Nerveux et sur l'Organe Electrique de la Torpille; par Paul Savi. 8vo. Paris, 1844.

Revision der Lehre vom Galvano-Voltaismus. Von C. H. Pfaff. 8vo. Altona. 1837.
Essai Historique sur les Phénomènes et les Doctrines d'Electro-Chimie, par E. F. Wartmann. 8vo. Genève, 1838.
Théorie Physique et Mathématique des Phénomènes Electro-dynamiques et du Magnétisme, par A. Masson. 8vo. Paris, 1838.
Das Verhalten des Eisens zum Sauerstoff, von L. F. Schönbein. 8vo. Basel, 1837.
Verhandeling over de Gutta Percha en Caoutchouc. Door A. Adriani. 8vo. Utrecht, 1850.
Recherches sur l'emploi de divers Amendements dans la Culture des Forêts, par M. E. Chevandier. 8vo. Paris, 1852.
Materials for a Fauna and Flora of Swansea and the Neighbourhood, by L. W. Dillwyn, F. R. S. 8vo. 1848.
Meditationes Analyticæ, by W. Spottiswoode. Part 1-5. 4to. 1837.
Monatsbericht der Königl. Preuss. Akademie, März, 1852. 8vo.

*Franklin Institute, Philadelphia* — Journal, Vol. XIII. No. 2, 3, 4. 8vo. 1852.
*Geological Society,*— Journal, No. 30. 8vo. 1852.
Anniversary Address, by W. Hopkins, Esq. 8vo. 1852.
*Kerr, (Mrs. Alexander) M.R.I.* — Code of Bugis Maritime Laws, with a Translation, Vocabulary, &c. 12mo. Singapore. 1832.
*Loseby, Mr. (the Author)* — Improvements in Timekeepers. 12mo. 1852.
*Lovell, E. B. Esq. (the Editor)* — The Monthly Digest for May, 1852. 8vo.
*Mantell, G. A. Esq., LL.D., F.R.S. (the Author)* — On the Fossil Remains of Reptiles, &c., from the Devonian Strata of Morayshire, &c. 8vo. 1852.
*Royal Society of London* — Transactions for 1851, Part II. 4to. 1852.
Proceedings, No. 76. 8vo. 1852.
*Rowcroft, Charles, Esq. (the Author)* — Confessions of an Etonian. 3 vols. 16mo. 1852.
*Scoffern, John, M. B. (the Editor)* — The Chemical Record for May, 1852. 4to.
*Sharp, Granville, Esq. (the Author)* — The Prize Essay on the Application of Recent Inventions collected at the Great Exhibition of 1851, to the purposes of Banking. 8vo. 1852.
*Vereins zur Beförderung des Gewerbfleisses in Preussen* — Verhandlungen, Jan. und Feb. 1852. 4to.
*Wilkinson, Sir J. Gardner, F. R. S. (the Author)* — The Fragments of the Hieratic Papyrus at Turin: containing the Names of the Egyptian Kings with the Hieratic Inscription at the back. Folio and 8vo. 1851.
*Weale, John, Esq.* — Rudimentary Treatises: 12mo. 1852.
The Marine Engine, &c. by R. Murray, C. E.
Astronomy, by the Rev. R. Main.
Integral Calculus, by H. Cox, B. A.
Differential Calculus, by W. S. B. Woolhouse, Esq.
Agricultural Engineering; Vol. I. Buildings; by G. H. Andrew.
Magnetism, Part III. by Sir W. Snow Harris, F.R.S.
Statics and Dynamics, by T. Baker, C. E.
Embanking, by John Wiggins, F. G. S.
*Zoological Society of London* — Transactions, Vol. IV. Part 2. 4to. 1852.

*Catherwood, Frederick, Esq.* — A Large Specimen of Auriferous Quartz from Gold Hill, Grass Valley, Nevada County, California.

## WEEKLY EVENING MEETING,

Friday, June 11.

Sir Charles Fellows, Vice-President, in the Chair.

Professor Faraday,

*On the Physical Lines of Magnetic Force.*

On a former occasion, (Jan. 23, 1852, see p. 105) certain lines about a bar magnet were described and defined (being those which are depicted to the eye by the use of iron filings sprinkled in the neighbourhood of the magnet), and were recommended as expressing accurately the nature, condition, direction, and amount of the force in any given region either within or outside of the bar. At that time the lines were considered in the abstract. Without departing from or unsettling any thing then said, the enquiry is now entered upon of the possible and probable *physical existence* of such lines. Those who wish to reconsider the different points belonging to these parts of magnetic science may refer to two papers in the first part of the Phil. Trans. for 1852 for data concerning the *representative* lines of force, and to a paper in the Phil. Mag. 4th Series, 1852, vol. iii. p. 401, for the argument respecting the *physical* lines of force.

Many powers act manifestly at a distance; their physical nature is incomprehensible to us: still we may learn much that is real and positive about them, and amongst other things something of the condition of the space between the body acting and that acted upon, or between the two mutually acting bodies. Such forces are presented to us by the phenomena of gravity, light, electricity, magnetism, &c. These when examined will be found to present remarkable differences in relation to their respective lines of forces; and at the same time that they establish the existence of real physical lines in some cases, will facilitate the consideration of the question as applied especially to magnetism.

When two bodies, *a*, *b*, gravitate towards each other, the line in which they act is a straight line, for such is the line which either would follow if free to move. The attractive force is not altered, either in *direction* or *amount*, if a third body is made to act by gravitation or otherwise upon either or both of the two first. A balanced cylinder of brass gravitates to the earth with a weight exactly the same, whether it is left like a pendulum freely to hang towards it, or whether it is drawn aside by other attractions or by tension, whatever the amount of the latter may be. A new gravitating force may be exerted upon *a*, but that does not in the least affect the amount of power which it exerts towards *b*. We have no evidence that *time*

enters in any way into the exercise of this power, whatever the distance between the acting bodies, as that from the sun to the earth, or from star to star. We can hardly conceive of this force in one particle by itself; it is when two or more are present that we comprehend it: yet in gaining this idea we perceive no difference in the character of the power in the different particles; all of the same kind are *equal, mutual,* and *alike.* In the case of gravitation, no effect which sustains the idea of an independent or physical line of force is presented to us; and as far as we at present know, the line of gravitation is merely an ideal line representing the direction in which the power is exerted.

Take the Sun in relation to another force which it exerts upon the earth, namely, its illuminating or warming power. In this case rays (which are lines of force) pass across the intermediate space; but then we may affect these lines by different media applied to them in their course. We may alter their direction either by reflection or refraction; we may make them pursue curved or angular courses. We may cut them off at their origin and then search for and find them before they have attained their object. They have a relation to *time,* and occupy 8 minutes in coming from the sun to the earth: so that they may exist independently either of their source or their final home, and have in fact a clear distinct physical existence. They are in extreme contrast with the lines of gravitating power in this respect; as they are also in respect of their condition at their terminations. The two bodies terminating a line of gravitating force are alike in their actions in every respect, and so the line joining them has like relations in both directions. The two bodies at the terminals of a ray are utterly unlike in action; one is a source, the other a destroyer of the line; and the line itself has the relation of a stream flowing in one direction. In these two cases of gravity and radiation, the difference between an abstract and a physical line of force is immediately manifest.

Turning to the case of Static Electricity we find here attractions (and other actions) at a distance as in the former cases; but when we come to compare the attraction with that of gravity, very striking distinctions are presented which immediately affect the question of a physical line of force. In the first place, when we examine the bodies bounding or terminating the lines of attraction, we find them as before, mutually and equally concerned in the action; but they are not alike: on the contrary, though each is endued with a force which speaking generally is of the like nature, still they are in such contrast that their actions on a third body in a state like either of them are precisely the reverse of each other,— what the one attracts the other repels; and the force makes itself evident as one of those manifestations of power endued with a dual and antithetical condition. Now with all such dual powers, attraction cannot occur unless the two conditions of force are present and in face of each other through the lines of force. Another essential limitation is that

these two conditions must be exactly equal in amount, not merely to produce the effects of attraction, but in every other case; for it is impossible so to arrange things that there shall be present or be evolved more electric power of the one kind than of the other. Another limitation is that they must be in physical relation to each other; and that when a positive and a negative electrified surface are thus associated, we cannot cut off this relation except by transferring the forces of these surfaces to equal amounts of the contrary forces provided elsewhere. Another limitation is that the power is definite in amount. If a ball *a* be charged with 10 of positive electricity it may be made to act with that amount of power on another ball *b* charged with 10 of negative electricity; but if 5 of its power be taken up by a third ball *c* charged with negative electricity, then it can only act with 5 of power on ball *a*, and that ball must find or evolve 5 of positive power elsewhere: this is quite unlike what occurs with gravity, a power that presents us with nothing dual in its character. Finally the electric force acts in curved lines. If a ball be electrified positively and insulated in the air, and a round metallic plate be placed about 12 or 15 inches off, facing it and uninsulated, the latter will be found, by the necessity mentioned above, in a negative condition; but it is not negative only on the side facing the ball but on the other or outer face also, as may be shewn by a carrier applied there, or by a strip of gold or silver leaf hung against that outer face. Now the power affecting this face does not pass through the uninsulated plate, for the thinnest gold leaf is able to stop the inductive action, but round the edges of the face and therefore acts in curved lines. All these points indicate the existence of physical lines of electric force: — the absolutely essential relation of positive and negative surfaces to each other, and their dependence on each other contrasted with the known mobility of the forces, admit of no other conclusion. The action also in curved lines must depend upon a physical line of force. And there is a third important character of the force leading to the same result, namely, its affection by media having different specific inductive capacities.

When we pass to Dynamic Electricity the evidence of physical lines of force is far more patent. A voltaic battery, having its extremities connected by a conducting medium, has what has been expressively called a current of force running round the circuit, but this current is an axis of power having equal and contrary forces in opposite directions. It consists of lines of force which are compressed or expanded according to the transverse action of the conductor, which changes in direction with the form of the conductor, which are found in every part of the conductor, and can be taken out from any place by channels properly appointed for the purpose; and nobody doubts that they are physical lines of force.

Finally as regards a Magnet, which is the object of the present discourse. A magnet presents a system of forces perfect in itself,

and able, therefore, to exist by its own mutual relations. It has the dual and antithetic character belonging to both static and dynamic electricity; and this is made manifest by what are called its polarities, *i. e.* by the opposite powers of like kind found at and towards its extremities. These powers are found to be absolutely equal to each other; one cannot be changed in any degree as to amount without an equal change of the other; and this is true when the opposite polarities of a magnet are not related to each other, but to the polarities of other magnets. The polarities, or the *northness* and *southness*, of a magnet are not only related to each other, through or within the magnet itself, but they are also related externally to opposite polarities, (in the manner of static electric induction) or they cannot exist; and this external relation involves and necessitates an exactly equal amount of the new opposite polarities to which those of the magnet are related. So that if the force of a magnet *a* is related to that of another magnet *b*, it cannot act on a third magnet *c* without being taken off from *b*, to an amount proportional to its action on *c*. The lines of magnetic force are shewn by the moving wire to exist both within and outside of the magnet; also they are shewn to be closed curves passing in one part of their course through the magnet; and the amount of those within the magnet at its equator is exactly equal in force to the amount in any section including the whole of those on the outside. The lines of force outside a magnet can be affected in their direction by the use of various media placed in their course. A magnet can in no way be procured having only one magnetism, or even the smallest excess of northness or southness one over the other. When the polarities of a magnet are not related externally to the forces of other magnets, then they are related to each other: *i. e.* the northness and southness of an isolated magnet are externally dependent on and sustained by each other.

Now all these facts, and many more, point to the existence of physical lines of force external to the magnets as well as within. They exist in curved as well as in straight lines; for if we conceive of an isolated straight bar magnet, or more especially of a round disc of steel magnetised regularly, so that its magnetic axis shall be in one diameter, it is evident that the polarities must be related to each other externally by curved lines of force; for no straight line can at the same time touch two points having northness and southness. Curved lines of force can, as I think, only consist with physical lines of force.

The phenomena exhibited by the moving wire confirm the same conclusion. As the wire moves across the lines of force, a current of electricity passes or tends to pass through it, there being no such current before the wire is moved. The wire when quiescent has no such current, and when it moves it need not pass into places where the magnetic force is greater or less. It may travel in such a course that if a magnetic needle were carried through the same course it would

be entirely unaffected magnetically, *i. e.* it would be a matter of absolute indifference to the needle whether it were moving or still. Matters may be so arranged that the wire when still shall have the same diamagnetic force as the medium surrounding the magnet, and so in no way cause disturbance of the lines of force passing through both; and yet when the wire moves, a current of electricity shall be generated in it. The mere fact of motion cannot have produced this current: there must have been a state or condition around the magnet and sustained by it, within the range of which the wire was placed; and this state shews the physical constitution of the lines of magnetic force.

What this state is or upon what it depends cannot as yet be declared. It may depend upon the ether, as a ray of light does, and an association has already been shewn between light and magnetism. It may depend upon a state of tension, or a state of vibration, or perhaps some other state analogous to the electric current, to which the magnetic forces are so intimately related. Whether it of necessity requires matter for its sustentation will depend upon what is understood by the term matter. If that is to be confined to ponderable or gravitating substances, then matter is not essential to the physical lines of magnetic force any more than to a ray of light or heat; but if in the assumption of an ether we admit it to be a species of matter, then the lines of force may depend upon some function of it. Experimentally mere space is magnetic; but then the idea of such mere space must include that of the ether, when one is talking on that belief; or if hereafter any other conception of the state or condition of space rise up, it must be admitted into the view of that, which just now in relation to experiment is called mere space. On the other hand it is, I think, an ascertained fact that ponderable matter is not essential to the existence of physical lines of magnetic force.

[M. F.]

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In the Library were exhibited:—

Specimen of Auriferous Quartz, Nevada County, California, presented by F. Catherwood, Esq.

Portrait of Mr. Faraday, by G. Richmond, Esq.; and of Dr. Roxburgh, by J. Z. Bell, Esq.

Axe (Marked Stanislaus, 1661), and Ancient Mace. [Exhibited by H. W. Pickersgill, Esq., R.A.]

"Solitude," designed by J. Lawlor, Esq. and executed by the Messrs. Minton, for the Art-Union of London. [Exhibited by T. S. Watson, Esq., M.R.I.]

Specimens of Iron Ore from Northants and of Malachite, from Siberia;—Black Marble Vases. [Exhibited by Mr. Tennant.]

Specimens of Bookbinding, by Messrs. J. and J. Leightons.
Stereoscope and Talbotypes, by Mr. Newman.
Pseudoscope and Objects. [Exhibited by Messrs. Watkins and Hill.]
Gazine Lamp, burning Spirit from Peat, by Mr. Reece.
Minerals and Fossils. [Exhibited by Mr. Highley, jun.]
Specimens of Beet-Sugar from Paris. [Exhibited by Mr. Duer.]
Painting, &c. on China. [Exhibited by W. Copeland, Esq.]
Specimens of Lead and Copper Ores, from Wales. [Exhibited by F. Lloyd, Esq., M.R.I.]
Flamingo, White Woodcock and Marmozets, mounted by Messrs. Leadbeaters.
Testimonial to Dr. Jeremie (in silver). [Exhibited by Messrs. Hunt and Roskell.]
Fish, Electrotyped from Nature, by Mr. J. How.
Talbotypes — Views in Edinburgh and Paris, Landscapes, &c. [Exhibited by Mr. Henneman.]
Specimens of Aloine. [Exhibited by T. N. R. Morson, Esq., M.R.I.]
Specimens of Work in Silver and Electrotype by Messrs. Elkingtons.
Model in white marble of the Memorial Pillar about to be erected at Ammerdown Park, Somerset, by Col. Jolliffe. [Exhibited by J. Jopling, Esq., the Architect.]
Mr. Varley exhibited by the Microscope Snails' eggs, the heart beating — Wheel Animalcules — Circulation of blood and peristaltic motion in small worms, and the circulation of sap in the Nitella.
Model of Richardson's Tubular Life-boat. [Exhibited by W. Varlo Hellyer, Esq., M.R.I.]

The Inventor, H. T. Richardson, Esq., in a paper accompanying the Model, stated that " the Tubular Life-boat cannot upset, sink or be water-logged, can beach through a heavy surf on any sandy or shingle shore, and pull off again without the aid of anchors; steers, rows, and sails well. Its extra buoyancy is six tons, exclusive of its own weight, which is within two; — it rows sixteen oars, and carries two lug sails, a jib and top sails — and can row and sail at the same time. In construction it is totally different from all other boats, being formed of two metal tubes forty feet in length, by two and a half diameter, tapering at either end in a manner so as to give the appearance of sheer. An iron framework securely rivetted unites the whole into one complete mass, the tubes having longitudinal bars of iron and hoops within, and iron keels running from end to end. They are divided into water-tight compartments, have air-proof bags in the four corners, and the two middle are filled with cork; a cork fender also surrounds the whole fabric. The rowers and passengers are placed on a platform above the frame-work, which is surmounted by a light gunwale the height of the row-locks; a rope passes along under the keelson for the purpose of towing."

## GENERAL MONTHLY MEETING,

### Monday, July 5,

**Sir Charles Fellows, Vice President, in the Chair.**

Charles Blakely Brown, M.D. Edwin Lankester, M.D. F.R.S. F.L.S. &c.
David Oldfield, Esq.

were *admitted* Members of the Royal Institution.

Sir George Pollock, G.C.B. Lieut.-Gen. in Hon. East India Company's Service

was duly *elected* a Member of the Royal Institution.

The Presents received since the last Meeting were laid on the Table and the thanks of the Members returned for the same.

From

*Her Majesty's Government* — Catalogue of Stars near the Ecliptic observed at Markree in 1848-50. Vol. I. 8vo. 1851.

*Astronomical Society, the Royal* — Monthly Notices. Vol. XII. No. 6. 8vo.

*Bell, Jacob, Esq. (the Editor)* — The Pharmaceutical Journal for June and July, 1852. 8vo.

*British Architects, Royal Institute of* — Proceedings for June, 1852. 4to.

*Chemical Society* — Quarterly Journal, No. 18. 8vo. 1852.

*Cornwall Polytechnic Society, the Royal* — The Nineteenth Annual Report. 8vo. 1851.

*Council of Education, Calcutta* — General Report on Public Instruction in the Lower Provinces of the Bengal Presidency, 1850-1. 8vo. 1852.
Annual Report of the Medical College of Bengal for 1851-2. 1852.

*Edinburgh Royal Observatory* — Astronomical Observations for 1844-7. Vol. X. 4to. 1852.

*Editors* — The Medical Circular for June, 1852. 8vo.
The Athenæum for May and June 1852. 4to.
The Practical Mechanic's Journal, Vol. I.-IV. and continuation. 1848-52.
Illustrated Index to Vol. I.-IV. 8vo. 1852.

*Faraday, M. Esq.* — Mémoires de l'Académie Royale des Sciences Morales et Politiques de l'Institut de France, tome V. VI. and VII. 4to. Paris. 1847-50.
Monatsbericht der Königl. Preuss. Akademie der Wissenchaften, Berlin. April, 1852. 8vo.
On the Physical Character of the Lines of Magnetic Force. 8vo. 1852.

*Grove, W. R. Esq. F.R.S. (the Author)* — On the Electro-Chemical Polarity of the Gases. 4to. 1852.

*Linnean Society of London* — Transactions, Vol. XX. Part 1. 4to. 1852.
Proceedings, No. 45, 46, 47. 8vo. 1851.
List of Members. 1851. 4to.

*Lovell, E. B. Esq. (the Editor)* — The Monthly Digest for June, 1852. 8vo.

*Newnham, Henry, Esq. M.R.I.* — History of the Twelve Great Livery Companies of London, by William Herbert. 2 vol. 8vo. 1837.

*Richers, Dr. Johannes (the Author)* — Natur und Geist. Erste Theil; Magnetismus, Galvanismus, und Elecktricität. 8vo. Leipzig, 1850.

*ty of London* — Proceedings, Vol. VI. No. 12. 8vo. 1852.
*r. J.* (*the Editor*) — The Chemical Record for June, 1852. 4to.
*Society of London* — Journal, Vol. XV. Part 2. 8vo. 1852.
*ır Beförderung des Gewerbfleisses in Preussen* — Verhandlungen, nd April. 4to. Berlin, 1852.
*n, Esq.* — Rudimentary Treatise on Civil Engineering; by H. Law, ıd on Hydraulic Engineering; by G. R. Burnell, C. E. Vol. III. Part 1. 1852.

[FOR THE USE OF MEMBERS.]

# Royal Institution of Great Britain.

## 1852.

### GENERAL MONTHLY MEETING,

Monday, November 1.

WILLIAM POLE, Esq., M.A., F.R.S., Treasurer and Vice-President, in the Chair.

Robert Pulsford, Esq.,

was duly *elected* a Member of the Royal Institution.

The following PRESENTS were announced; and the thanks of the Members returned for the same: —

FROM

*Actuaries, Institute of* — The Assurance Magazine, No. 8 & 9. 8vo. 1852.
Catalogue of Library. 8vo. 1852.
*Agricultural Society of England* (*Royal*) — Journal, Vol. XIII. Part 1. 8vo. 1852.
*American Academy of Arts and Sciences* — Memoirs, New Series, Vol. IV. Part 2. 4to. 1850.
*American Philosophical Society* — Proceedings, No. 47. 8vo. 1852.
*Antiquaries, Society of, London* — Archæologia, or Miscellaneous Tracts relating to Antiquity. Vol. XXXIII. and XXXIV. 4to. 1849-52.
Proceedings, Vol. I. and No. 18-32. 8vo. 1843-52.
*Asiatic Society, Royal* — Twenty-ninth Annual Report. 8vo. 1852.
*Asiatic Society of Bengal* — Journal, No. 226, 227. 8vo. 1852.
*Author* — An Excursion from Jericho to the Ruins of the Ancient Cities of Geraza and Amman in the country east of the River Jordan. 8vo. 1852.
*Ball, Robert, Esq. LL. D.* (*the Secretary*) — Report on the Condition and Progress of the Queen's University in Ireland, for the year ending June 19, 1852, by the Right Hon. M. Brady, Vice-Chancellor of the University. Folio. 1852.
*Bell, Jacob, Esq.* (*the Editor*) — The Pharmaceutical Journal for August, September, and October, 1852. 8vo.
*Billing, A., M.D., F.R.S.* (*the Author*) — Practical Observations on Diseases of the Lungs and Heart. 8vo. 1852.
*British Architects, Royal Institute of* — Proceedings, July, 1852. 4to.
*British Association for the Advancement of Science* — Report of the Twenty-first Meeting held at Ipswich in July, 1851. 8vo. 1852.
*Chemical Society* — Quarterly Journal, No. 19. 8vo. 1852.
*Commissioner of Patents, United States* — Report, Part II.; Agriculture. 8vo. 1851.
United States' Patent Laws. 8vo. 1851.
Information to Persons having Business to transact at the Patent Office. 8vo. 1851.
*East India Company* — Third Report of the Students' Literary and Scientific Society, Bombay. 8vo. 1852.
*The Editors* — The Athenæum, for July — October, 1852. 4to.
The Medical Circular for July — October, 1852. 4to.
The Practical Mechanic's Journal for July — October, 1852. 4to.
The Chemical Record for July and August, 1852. 4to.

*Faraday, Professor* — Atti dell' Accademia Pontificia de' Nuovi Lincei; Tomo I. Anno I. ed Anno IV. Sessione 7, 8, 9. 4to. 1852.
Monatsbericht der Königl. Preuss. Akademie, Mai — Aug., 1852. 8vo. Berlin.
Sitzungsberichte de Kaiserlichen Akademie, zu Wien:—
Math. Nat. Classe. Band VIII. Hefte 1, 2, 3. 8vo. 1852.
Phil. Hist. Classe. Band VIII. Hefte 1, 2. 8vo. 1852.
Archiv für Kunde Œsterreichischer Geschichts-quellen. Band VII. Hefte 3, 4. 8vo. 1852.
Notizenblatt, No. 3 — 10. 8vo. 1852.
Almanach der Kaiserlichen Akademie zu Wien. 2ter Jahrgang, 1852. 16mo. 1852.
Tafeln zur Reduction der Barometerstände; und Tafeln zur Vergleichung und Reduction der Barometerstände. Von J. J. Pohl und J. Schabus. 8vo. 1852. Wien.
Experimental Researches in Electricity, 29th Series, by M. Faraday, Esq. D.C.L. 4to. 1852.
Kalender der Flora des Horizontes von Prag. Von Karl Fritsch. 8vo. 1852.
Abhandlungen der Königl. Preuss. Akademie, 1850. 4to. Berlin, 1852.
Jaarboekje van Wetenschapen en Kunsten, Vifde Jaargang. Door S. Bleekrode. 12mo. Gorinchem, 1851-2.

*Franklin Institute of Pennsylvania*— Journal, Vol. XXI.; Vol. XXIII. Nos. 5, 6, and Vol. XXIV. No. 1. 8vo. 1851-2.

*Geological Society*,— Quarterly Journal, No. 31. 8vo. 1852.

*Granville, A. B., M.D., F.R.S., (the Author)*— Two Letters on the Great Artesian Salt Spring at Kissingen. 4to. 1852.

*Hamilton, Edward, M.D., F.L.S., M.R.I. (the Author)* — The Flora Homœopathica; or, Illustrations and Descriptions of Medicinal Plants used as Homœopathic Remedies. Vol. I. 8vo. 1852.

*Highley and Son, Messrs.*— Brief Astronomical Tables for the Expeditious Calculation of Eclipses. By W. D. Snooke. 8vo. 1852.

*Hookham, Mr. (the Publisher)* — The New Quarterly Review, No. III. 8vo. 1852.

*Horticultural Society of London* —Journal, Vol. VII. Parts 3, 4. 8vo. 1852.

*Jones, H. Bence, M.D., F.R.S., M.R.I. (the Editor)* — On Animal Electricity; being an Abstract of the Discoveries of Emil Dubois-Reymond. 16mo. 1852.
Manual of Elementary Chemistry, by George Fownes, F.R.S. 4th Edition. Edited by H. Bence Jones, M.D., F.R.S., and A. W. Hofmann, F.R.S., Ph. D. 16mo. 1852.

*Jones, T. Wharton, Esq., F.R.S., (the Author)* — On the Rhythmical Contractility of the Veins of the Bat's Wing. 4to. 1852.

*Lankester, E., M.D., F.R.S., M.R.I.*,—Microscopical Examination of the Thames and other Waters, by E. Lankester, M.D., F.R.S. and Peter Redfern, M.D., F.R.C.S.L. 8vo. 1852.

*Lovell, E. B. Esq., M.R.I. (the Editor)*—The Monthly Digest for July — October, 1852. 8vo.

*Murchison, Sir R. I., G.C. St. S., F.R.S., Pres. R.G.S., M.R.I. (the Author)* — Address at the Anniversary Meeting of the Royal Geographical Society, May 24, 1852. 8vo. 1852.
Catalogue of the Library of the Royal Geographical Society corrected to May, 1851. 8vo. 1852.

*Neale, E. Vansittart, Esq., M.R.I.* — Transactions of the Co-operative League, Parts I. and II. 8vo. 1852.

*Petermann, Augustus, F.R.G.S. (the Author)*—The Search for Franklin. A Suggestion submitted to the British Public. 8vo. 1852.

*Physicians, Royal College of, London* — Catalogue of Fellows, &c. 8vo. 1852.

*Radcliffe Trustees, Oxford* — Astronomical Observations made at the Radcliffe Observatory, Oxford, in 1850. 8vo. 1852.

*Royal Society of London*—Proceedings, Vol. VI. No. 88, 89, 90. 8vo. 1852.

*Royal Society of Edinburgh* — Transactions, Vol. XX. Part 2. 4to. 1852.
Proceedings, No. 42. 8vo. 1852.

*Smithsonian Institution, Washington, U. S.* — Smithsonian Contributions to Knowledge, Vols. III. and IV. 4to. 1852.
Fifth Annual Report of the Board of Regents. 8vo. 1851.
Smithsonian Report on Recent Improvements in the Chemical Arts, by Professor J. C. Booth, and Campbell Morfit. 8vo. 1851.
Directions for Collecting Specimens of Natural History. 8vo. 1852.
Registry of Periodical Phenomena. fol.
Abstract of the Seventh Census, United States. 4to. 1851.
American Zoological, Botanical, and Geological Bibliography for 1851. 8vo. 1852.
Tables used with Custom-House Hydrometers. 8vo. 1851.

*Société de Physique et d'Histoire Naturelle de Genève*—Mémoires, Tome XIII. 1re Partie. 4to. Genève, 1852.

*Statistical Society of London* — Journal, Vol. XV. Part 3. 8vo. 1852.

*Surgeons of England, Royal College of*—List of Fellows and Members. 8vo. 1852.

*Vereins zur Beförderung des Gewerbfleisses in Preussen* — Verhandlungen, Mai und Juni, 1852. 4to. Berlin.

*Warren, John C., M.D. (the Author)*—Description of a Skeleton of the Mastodon Giganteus of North America. 4to. Boston, U. S. 1852.

*Weale, John, Esq.* — The Electric Telegraph, its History and Progress: by Edward Highton, C. E. 12mo. 1852.
Lexicon of the Greek Language: By H. R. Hamilton. Part I. 12mo. 1852.
Grammar of the Spanish Language: By A. Elwes. 12mo. 1852.
Grammar of the Italian Language: By A. Elwes. 12mo. 1852.

*Vyvyan, Sir R. R. Bt. M.P., F.R.S., M.R.I.* — Two Grove's Cells, with plates and acids.

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## GENERAL MONTHLY MEETING,

Monday, Dec. 6.

Sir Charles Fellows, Vice-President, in the Chair.

John Elijah Blunt, Esq., Master in Chancery.
Rev. John Harris, D.D., Principal of New College, St. John's Wood.
Rev. George Heathcote, M.A., Rector of Conington, Hants.
Henry Ludlam, Esq.
Henry M. Noad, Esq., Ph.D. Professor of Chemistry, St. George's Hospital.
John Rutherford, Esq.
Rev. Thomas Fraser Stooks, M.A.
Emilius Watson-Taylor, Esq.
William Watt, Esq.

were duly *elected* Members of the Royal Institution,

The Secretary reported that the following Arrangements had been made for the Lectures before Easter, 1853:

Six Lectures on Chemistry (adapted to a Juvenile Auditory,)—by Michael Faraday, Esq., F.R.S., &c., Fullerian Professor of Chemistry, R. I.

Twelve Lectures on Animal Physiology — by T. Wharton Jones, Esq. F.R.S., Fullerian Professor of Physiology, R. I.

Nine Lectures on the General Principles of Geology — by John Phillips, Esq., F.R.S., F.G.S.

Nine Lectures on the Philosophy of Chemistry—by ALEXANDER W. WILLIAMSON, Ph. D., Professor of Practical Chemistry in University College, London.

(*Laboratory Lectures.*) Twenty Lectures on Organic Chemistry—by Dr. A. W. HOFMANN, F.R.S., Professor in the College of Chemistry, London.

The following PRESENTS were announced, and the thanks of the Members returned for the same;—

FROM

*Asiatic Society of Bengal*—Journal, No. 220, 228. 8vo. 1851-2.
*Asiatic Society, Royal*—Journal, Vol. XIII. Part 2. 8vo. 1852.
*Astronomical Society, Royal*—Monthly Notices, No. 7. 8vo. 1852.
*Bell, Jacob, Esq. M.R.I. (the Editor)*—The Pharmaceutical Journal for Nov. and Dec. 1852. 8vo.
*British Architects, Royal Institute of*—Proceedings for Nov. 1852. 4to.
*Civil Engineers, Institution of*—Proceedings for Nov. 1852. 8vo.
*Editors*—The Practical Mechanic's Journal for Nov. 1852. 4to.
The Medical Circular for Nov. 1852. 4to.
*Geological Society*—Quarterly Journal, No. 32. 8vo. 1852.
*Glasgow Philosophical Society*—Proceedings, Vol. IV. No. 4, 8vo. 1852.
*Hamel, Dr. J., (the Author)*—Der Dodo, die Einsiedler und die Erdichtete Nazarvogel. 8vo. St. Petersburg, 1848.
*London (Watford) Spring Water Company, Directors of the*—Report. 8vo. 1852.
Microscopical Examinations, &c. of the Thames and other Waters. 8vo. 1852.
*Lovell, E. B. Esq., M.R.I. (the Editor)*—The Monthly Digest, Nov. 1852. 8vo.
*Medical and Chirurgical Society, Royal*—Medico-Chirurgical Transactions, Vol. XXXIV. and XXXV. 8vo. 1851-2.
*Pollock, W. F. Esq., M.R.I.*—An Essay on the Action of Medicines on the System. (Fothergill Prize Essay.) By F. W. Headland, B.A., M.R.C.S. 8vo. 1852.
*Scoffern, John, M.B.*—Tacitus. Ed. Elzevir. 32mo. Amstelodami, 1665.
*Society of Arts*—Journal, No. 1. 8vo. 1852.
*Taylor, Alfred S., M.D., F.R.S., M.R.I. (the Author)*—Medical Jurisprudence. Fourth Edition. 16mo. 1852.
*Taylor, Rev. W., F.R.S., M.R.I., (the Editor)*—The Diagrams of Euclid's Elements of Geometry, in an Embossed or Tangible Form for the Use of Blind Persons, Part I. 8vo. 1828.
Selection of Psalm-Tunes and Chants in Raised or Embossed Characters for the Use of the Blind. folio. 1836.
*Vereins zur Beförderung des Gewerbfleisses in Preussen*—Verhandlungen, Juli und August, 1852. 4to. Berlin, 1852.
*Weale, John, Esq.*—Grammar of the German Language by G. L. Strauss, Ph. D. 12mo. 1852.
German Reader, Edited by G. L. Strauss, Ph. D. 12mo. 1852.
Grammar of the English Tongue, Spoken and Written. By Hyde Clarke. 12mo. 1852.
Outlines of the History of England, by W. D. Hamilton, Vol. I. 12mo. 1852.
First Mnemonical Lessons in Geometry, Algebra, and Trigonometry, by the Rev. T. P. Kirkman. 12mo. 1852.
Elements of Mechanism, by T. Baker, C. E. 12mo. 1852.
Rudimentary Treatise on Agricultural Engineering, by G. H. Andrews, Vol. I. Motive Powers. 12mo. 1852.
Rudimentary Treatise on Civil Engineering, Vol. III. Pt. 2. 12mo. 1852.
*Whewell, Rev. W., D.D., Master Trin. Coll. Camb. (the Author)*—Letter to the Author of "Prolegomena Logica." 8vo. 1852.

## 1853.

### WEEKLY EVENING MEETING,

Friday, January 21.

William Pole, Esq., M.A., F.R.S., Treasurer and Vice-President, in the Chair.

Professor Faraday,

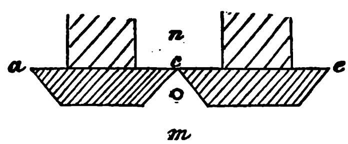
*Observations on the Magnetic Force.*

Inasmuch as the general considerations to be brought forward had respect to those great forces of the globe, exerted by it, both as a mass and through its particles, namely, Magnetism and Gravitation, the attention was first recalled briefly to certain relations and differences of the two which had been insisted upon on former occasions. Both can act at a distance, and doubtless at any distance : but whilst gravitation may be considered as simple and unpolar in its relations, magnetism is dual and polar. Hence *one* gravitating particle or system cannot be conceived to act by gravitation, as a particle or system, on itself; whereas a magnetic particle or system, because of the dual nature of its force, can have such a self relation. Again, either polarity of the magnetic force can act either by attraction or repulsion; and not merely so, but the joint or *dual* action of a magnet can act also either by attraction or repulsion, as in the case of paramagnetic and diamagnetic bodies : the action of gravity is always that of attraction. As a further consequence of the difference in character of the powers, little or no doubt was entertained regarding the existence of physical lines of force* in the cases of dual powers, as electricity and magnetism; but in respect of gravitation the conclusion did not seem so sure. As some further relations of the sun and the earth would have finally to be submitted, the audience were reminded, by the use of Arago's idea, of the relative magnitude of the two; for, supposing that the centres of the two globes were made to coincide, the sun's body would not only extend as far as the moon, but nearly as far again, its bulk being about seven times that of a globe which should be girdled by the moon's orbit.

For the more careful study of the magnetic power a torsion balance had been constructed, which was now shown and its mode of operation explained. The torsion wire was of hard drawn platinum, 24 inches in length, and of such diameter that 28.5 inches

* Proceedings of the Royal Institution, June 11, 1852, p. 216, also Philosoph. Mag. 4th Series, 1852, III. p. 401.

weighed one grain. It was attached as usual to a torsion head and index. The horizontal beam was a small glass tube terminated at the object end by a glass hook. The objects to be submitted to the magnetic force were either cylinders of glass with a filament drawn out from each, so as to make a long stiff hook for suspension from the beam; or cylindrical bulbs of glass, of like shape, but larger size, formed out of glass tube; or other matters. The fine tubular extremities of the bulbs being opened the way through was free from end to end; the bulbs could then be filled with any fluid or gas, and be re-submitted many times in succession to the magnetic force. The source of power employed was at first a large electro-magnet; but afterwards, in order to be certain of a constant power, and for the advantage of allowing any length of time for the observations, the great magnet, constructed by M. Logeman upon the principles developed by Dr. Elias, (and which, weighing above 100 lbs. could support 430 lbs. according to the report of the Great Exhibition Jury), was purchased by the Royal Institution and used in the enquiries. The magnet was so arranged that the axis of power was five inches below the level of the glass beam, the interval being traversed by the suspension filament or hook, spoken of above. The form and position of the terminations of soft iron are shewn in plan by the diagram upon a scale of $\frac{1}{10}$, and also the place of the object. All




this part is enclosed in the box which belongs to and carries the torsion balance, which box is governed by six screws fixed upon the magnet table; and as both the box and the table have lines and scales marked upon them, it is easy to adjust the former on the latter so that the beam shall be over and parallel to the line *a*, *e* with the point of suspension over *c*; or, by moving the whole box parallel to itself towards *m*, to give the point of suspension any other distance from the angle *c*. As already said, the objects were constructed with a suspension filament of such length as to make them coincide in height with the angle in the magnetic field. When suspended on the beam they were counterpoised by a ring or rings of lead on the further arm of the beam. These when required were moved along the beam until the latter was horizontal; and that state was ascertained by a double arm support, which sustained the beam when out of use, brought it into a steady state when moving, and delivered it into a condition of freedom when required. The motion of the box to the right or left, so as to place the object in the middle of the magnetic angle, was given by two

of the screws before spoken of; the motion to the given distance from $c$, by the other four.

Supposing the distance from $c$ towards $m$ to be adjusted to 0.6 of an inch, when the beam was loaded above, and no object before the magnet (the beam having been of course previously adjusted to its normal position and the torsion index placed at zero), it then remained to determine the return of the beam to its place when the object had been suspended on it and repelled: this was done in the following manner. A small plane reflector is fixed on the beam, near its middle part, under the point of suspension: a small telescope associated with a divided scale is placed about 6 feet from the reflector, and in such a position that when the beam is in its right place, a given degree in the scale coincides with the fine wire in the telescope. Of course the scale appears to pass by the wire as the beam itself moves, and with a double angular velocity, because of the reflexion. As it is easy to read to the fiftieth and even to the hundredth of an inch in this way, and as each degree occupies apparently 2.4 inches with the radius of 6 feet, so an angular motion, or difference of $\frac{1}{240}$ of a degree could be observed; and as the radius of the arm of the beam carrying the object was 6 inches, such a quantity there would be less than $\frac{1}{2000}$ of an inch: *i. e.* the return of the beam to its first or normal position by the torsion force put on to counteract the repulsion, could be ascertained to within that amount. When an object was put on the adjusted beam, if diamagnetic it was repelled; and then, as the observer sat at the telescope, he, by means of a long handle, a wheel, and pinion, put on torsion until the place of the beam was restored; and afterwards the amount of torsion read off on the graduated scale became the measure in degrees of the repulsive force exerted. At the time of real observations, the magnet, balance, and telescope were all fixed in a basement room, upon a stone floor. But it is unnecessary to describe here the numerous precautions required in relation to the time of an observation, the set of the suspension wire by a high torsion, the possible electricity of the object or beam by touch, the effect of feeble currents of air within the box, the shape of the object, the precaution against capillary action when fluids were employed as media, and other circumstances; or the use of certain stops, and the mode of procedure in the cases of paramagnetic action; — the object being at present to present only an intelligible view of the principles of action.

When a body is submitted to the power of a magnet, it is affected, as to the result, not merely by the magnet, but also by the medium surrounding it; and even if that medium be changed for a vacuum, the vacuum and the body still are in like relation to each other. In fact the result is always differential; any change in the medium changes the action on the object, and there are abundance of substances which when surrounded by air are repelled, and when by water, are attracted, upon the approach of a magnet. When a certain small

glass cylinder weighing only 66 grains surrounded by air was submitted on the torsion balance to the Logeman magnet at the distance of 0.5 of an inch from the axial line, it required 15° of torsion to overcome the repulsive force and restore the object to its place. When a vessel of water was put into the magnetic field, and the experiment repeated, the cylinder being now in the water was attracted, and 54°.5 of torsion were required to overcome this attraction at the given distance of 0.5. If the vessel had contained a fluid exactly equal in diamagnetic power to the cylinder of glass, neither attraction nor repulsion would have been exerted on the latter, and therefore the torsion would have been 0°. Hence the three bodies, air, glass (the especial specimen), and water, have their relative force measured in relation to each other by the three experimental numbers 15°, 0°, and 54°5. If other fluids are taken, as oil, ether, &c. and employed as the media surrounding the *same glass cylinder*, then the degrees of torsion obtained with each of them respectively, shews its place in the magnetic series. It is the principle of the hydrometer or of Archimedes in respect of gravity applied in the case of the magnetic forces. If a different cylinder be employed of another size or substance, or at a different distance, the torsion numbers will be different, and the zero (given by the cylinder) also different; but the media (with an exception to be made hereafter) will have the same relation to each other as in the former case. Therefore to bring all the experimental results into one common relation, a centigrade scale has been adopted bounded by air and water at common temperatures or 60° F. For this purpose every separate series of results made under exactly the same circumstances included air and water; and then all the results of one series were multiplied by such a number as would convert the difference between air and water into 100°: in this way the three results given above, become 21°.6; 0°; and 78°.4. By such a process the magnetic intervals between the bodies are obtained on the centigrade scale, but the true zero is not as yet determined. Either water, or air, or the glass, may be assumed as the zero, the intervals not being in any way dependent upon that point, but the results will then vary in expression thus:—

| | | | |
|---|---|---|---|
| Air . | 0° . | 21°.6 . | 100° |
| Glass . | 21°.6 . | 0° . | 78°.4 |
| Water . | 100° . | 78°.4 . | 0° |

all above the zero being paramagnetic, and all below diamagnetic, in relation to it. I have adopted a vacuum as the zero in the table of results to be given hereafter.

In this manner it is evident that upon principle, any solid, whatever its size, shape, or quality, may be included in the list, by its subjection to a magnet in air and in water or in fluids already related to these: also that any fluids may be included by the use of the *same* immersed solid body for them, air and water; and also that by using the same vessel, as for instance the same glass bulb,

and filling it successively with various gases and fluids, including always air and water in each series, these included bodies may then have their results reduced and be entered upon the list. The following is a table of some substances estimated on the centigrade scale, and though there are many points both of theory and practice yet to be wrought out, as regards the use of the torsion balance described, so that the results can only be recorded as approximations, yet even now the average of three or four careful experiments, gives an expression for any particular substance under the same conditions of distance, power, &c. near upon and often within a degree of the place assigned to it. The powers are expressed for a distance of 0.6 of an inch from the magnetic axis of the magnet as arranged and described, and, of course, for *equal volumes* of the bodies mentioned. The extreme decimal places must not be taken as indicating accuracy, except as regards the record of the experiments: they are the results of calculation. Hydrogen, nitrogen, and perhaps some other of the bodies near zero, may ultimately turn out to be as a vacuum; it is evident that a very little oxygen would produce a difference, such as that which appears in nitrogen gas. The first solution of copper mentioned was colourless, and the second the same solution oxidized by simple agitation in a bottle with air, the copper, ammonia, and water being in both the same.

| | | | |
|---|---|---|---|
| Prot-ammo. of copper | 134°.23 | Camphor . . . | 82°.59 |
| Per-ammo. of copper | 119.83 | Camphine . . | 82.96 |
| Oxygen . . . | 17.5 | Linseed oil . . | 85.56 |
| Air . . . . | 3.4 | Olive oil . . . | 85.6 |
| Olefiant gas . . | 0.6 | Wax . . . . | 86.73 |
| Nitrogen . . . | 0.3 | Nitric acid . . | 87.96 |
| Vacuum . . . | 0.0 | Water . . . . | 96.6 |
| Carbonic acid gas . | 0.0 | Solution of Ammonia. | 98.5 |
| Hydrogen . . . | 0.1 | Bisulphide of carbon | 99.64 |
| Ammonia gas . . | 0.5 | Sat. sol. Nitre . . | 100.08 |
| Cyanogen . . . | 0.9 | Sulphuric acid . . | 104.47 |
| A Glass . . . | 18.2 | Sulphur . . . | 118. |
| Pure Zinc . . . | 74.6 | Chloride of Arsenic . | 121.73 |
| Ether . . . . | 75.3 | Fused Borate lead . | 136.6 |
| Alcohol absolute . | 78.7 | Phosphorus . . | |
| Oil of Lemons . . | 80. | Bismuth . . . | 1967.6 |

Plücker in his very valuable paper* has dealt with bodies which are amongst the highly paramagnetic substances, and his estimate of power is made for equal weights.

One great object in the construction of an instrument delicate as that described, was the investigation of certain points in the philosophy of magnetism; and amongst them especially that of the right application of the law of the inverse square of the distance as the universal law of magnetic action. Ordinary magnetic

* Taylor's Scientific Memoirs, V. 713, 730.

action may be divided into two kinds, that between magnets permanently magnetized and unchangeable in their condition, and that between bodies of which one is a permanent unchangeable magnet, and the other, having no magnetic state of its own, receives and retains its state only whilst in subjection to the first. The former kind of action appears in the most rigid and pure cases, to be subject to that law; but it would be premature to assume beforehand, and without abundant sufficient evidence, that the same law applies in the second set of cases also; for a hasty assumption might be in opposition to the truth of nature, and therefore injurious to the progress of science, by the creation of a preconceived conclusion. We know not whether such bodies as oxygen, copper, water, bismuth, &c., owe their respective paramagnetic and diamagnetic relation to a greater or less facility of conduction in regard to the lines of magnetic force, or to something like a polarity of their particles or masses, or to some as yet unsuspected state; and there is little hope of our developing the true condition, and therefore the cause of magnetic action, if we assume beforehand the unproved law of action and reject the experiments that already bear upon it: — for Plücker has distinctly stated as the fact, that diamagnetic force increases more rapidly than magnetic force, when the power of the dominant magnet is increased; and such a fact is contrary to the law above enunciated. The following are further results in relation to this point.

When a body is submitted to the great unchanging Logeman magnet in air and in water, and the results are reduced to the centigrade scale, the relation of the three substances remain the same for the same distance, but not for *different* distances. Thus when a given cylinder of flint glass was submitted to the magnet surrounded by air and by water, at the distance of 0.3 of an inch as already described, it proved to be diamagnetic in relation to both; and when the results were corrected to the centigrade scale, and water made zero, it was 9°.1 below, or on the diamagnetic side of water. At the distance 0.4 of an inch it was 10°.6 below water: at the distance of 0.7 it was 12°.1 below water. When a more diamagnetic body, as heavy glass, was employed, the same result in a higher degree was obtained; for at the distance of 0.3 it was 37°.8 below water, and at that of 0.8 it was 48°.6 beneath it. Bismuth presented a still more striking case, though, as the volume of the substance was necessarily small, equal confidence cannot be placed in the exactitude of the numbers. The results are given below for the three substances, air being always 100° and water 0°; the first column of figures for each substance contain the distance *

* A given change of distance necessarily implies change in degree of force, and change in the forms of the lines of force; but it does not imply always the same amount of change. The forces are not the same at the same distance of 0.4 of an inch in opposite directions from the axial line towards *m* and *n* in the figure, page 230, nor at any other equal moderate distance; and though by increase and diminution of distance the change is in the same direction, it

in tenths of an inch from the axial line of the magnetic field, and the second, the place in centigrade magnetic degrees below water.

| Flint Glass. | Heavy Glass. | Bismuth. |
|---|---|---|
| 0.3 — 9°.1 | 0.3 — 37°.8 | 0.6 — 1871°. |
| 0.4 — 10.6 | 0.4 — 38.6 | 1.0 — 2734. |
| 0.5 — 11.1 | 0.6 — 40.0 | 1.5 — 3626. |
| 0.6 — 11.2 | 0.8 — 48.6 | |
| 0.7 — 12.1 | 1.0 — 51.5 | |
| | 1.2 — 65.6 | |

The result here is that the greater the distance of the diamagnetic bodies from the magnet, the more diamagnetic is it in relation to water, taking the interval between water and air as the standard: and it would further appear, if an opinion may be formed from so few experiments, that the more diamagnetic the body compared to air and water, the greater does this difference become. At first it was thought possible that the results might be due to some previous state induced upon the body, by its having been nearer to or further from the magnet: but it was found that whether the progress of the experiments was from small to large distances, or the reverse; or whether, at any given distance, the object was previous to the measurement held close up to the magnet or brought from a distance, the results were the same;— no evidence of a temporary induced state could in any of these ways be found.

It does not follow from the experiments, if they should be sustained by future researches, that it is the glass or the bismuth only that changes in relation to the other two bodies. It may be the oxygen of the air that alters, or the water, or more probably all these bodies: for if the result be a true and natural result in these cases, it is probably common to all substances. The great point is that the three bodies concerned, air, water, and the subject of the experiment, alter in the degree of their magnetic relations to *each other;* at different given distances from the magnet the ratio of their magnetic power does not, according to the experiments, remain the same; and if that result be confirmed, then it cannot be included by a law of action which is inversely as the square of the distance. A hydrometer floating in a fluid and subject to the gravity of the earth alone, would (other things being the same) stand at the same point, whether at the surface of the earth, or removed many diameters of the earth from it, because the action of gravity is inversely as the square of the distance: but if we suppose the substance of the hydrometer and the fluid to differ magnetically, as water and bismuth does, and the earth to act as a magnet instead of by gravity, then the hydrometer would, according to the experiments, stand at a different point for different distances, and if so could not be subject to the former law.

is not in the same proportion. By fitly arranged terminations, it may be made to alter with extreme rapidity in one direction, and with extreme slowness or not at all in another.

The cause of this variation in the ratio of the substances one to another, if it be finally proved, has still to be searched out. It may depend in some manner upon the *forms* of the lines of magnetic force, which are different at different distances; or not upon the forms of the lines but the *amount* of power at the different distances; or not upon the mere amount, but on the circumstance that in every case the body submitted to experiment has lines of *different degrees of force* passing through different parts of it, (for however different the magnetic or diamagnetic conditions of a body and the fluid surrounding it, they would not move at all in relation to each other in a field of equal force): but whatever be the cause, it will be a concomitant of magnetic actions; and therefore ought to be included in the results of any law by which it is supposed that these actions are governed.

It has not yet been noticed that these general results appear to be in direct opposition to those of Plücker, who finds that diamagnetic power increases more rapidly than magnetic power with increase of force. But such a circumstance, if both conclusions be accordant with facts, only shews that we have yet a great deal to learn about the physical nature of magnetic force; and we must not shut our eyes to the first feeble glimpses of these effects, because they are inconsistent on both sides with our assumed laws of action; but rather seize them, as hoping that they will give us the key to the truth of nature. Bodies, when subject to the power of the magnet appear to acquire a new physical state, which varies with the distance or the power of the magnet. Each body may have its own rate of increase and decrease; and that may be such as to connect the extreme effect of Plücker, amongst paramagnetic bodies on the one hand, and the extreme effects amongst diamagnetic bodies now described, on the other; and when we understand all this rightly, we may see the apparent contradiction become harmony, though it may not conform to the law of the inverse square of the distance as we now try to apply it.

Plücker has already said, because of his observations regarding paramagnetic and diamagnetic force, that no correct list of magnetic substances can be given. The same consequence follows, though in a different direction from what has now been stated, and hence the reservation before made (p. 232). Still the former table is given as an approximation, and it may be useful for a time. Before leaving his first account of recent experimental researches, it may be as well to state that they are felt to be imperfect and may perhaps even be overturned; but, that as such a result is not greatly anticipated, it was thought well to present them to the Members of the Royal Institution and the scientific world, if peradventure they might excite criticism and experimental examination, and so aid in advancing the cause of physical science.

On a former occasion * the existence of *physical* lines of force in

* Proceedings of the Royal Institution, p. 216.

relation to magnetism and electricity was inferred from the dual nature of these powers, and the necessity in all cases and at all times of a relation and dependence between the polarities of the magnet, or the positive and negative electrical surfaces. With respect to gravity a more hesitating opinion was expressed, because of the difficulty of observing facts having any relation to *time*, and because two gravitating particles or masses did not seem to have any necessary dependence on each other for the existence or excitement of their mutual power*. On the present occasion a passage was quoted from Newton which had since been discovered in his works, and which, shewing that he was an unhesitating believer in physical lines of gravitating force, must from its nature, rank him amongst those who sustain the physical nature of the lines of magnetic and electrical force: it is as follows, in words written to Bentley: † "That gravity should be innate, inherent and essential to matter, so that one body may act upon another at a distance through a *vacuum*, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man who has in philosophical matters a competent faculty of thinking, can ever fall into it. Gravity must be caused by an agent acting constantly according to certain laws; but whether this agent be material or immaterial, I have left to the consideration of my readers."

Finally, reference was made to Sabine's remarkable observation, sustained as it has been by Wolf, Gautier, and others, of certain coincidences existing between the appearance of solar spots and the diurnal variation of the magnetism of the earth. SCHWABE has been engaged in carefully observing the spots on the Sun since the year 1826. He has found them gradually to increase in number and size from year to year, and then decrease; then again increase, again to decrease, and so on in a regular period of about ten years. The following is a part of his table ‡ giving the years of the maxima and minima of spots:

| | Groups in the year. | Days of no spots. | Days of observation. |
|---|---|---|---|
| 1826 | | | |
| 1828 | .. 225 .. | .. 0 .. | .. 282 |
| 1833 | ... 33 ... | ... 139 ... | ... 267 |
| 1837 | .. 333 .. | .. 0 .. | .. 168 |
| 1843 | ... 34 ... | ... 149 ... | ... 312 |
| 1848 | .. 330 .. | .. 0 .. | .. 278 |
| 1851 | | | |

* Philosophical Magazine, 4th Series, 1852, III. 403. (3246.)

† Newton's Works, Horsley's edition, 4to. 1783, Vol. IV. p. 438, or the Third Letter to Bentley.

‡ Humboldt's Cosmos, III. 291, 292. Bibliothèque Universelle, 1852, XX. 184.

Lamont (Dec. 1851)* was induced by recent researches in atmospheric magnetism, to examine the daily magnetic variation in declination, and found that, as a whole, it increased and diminished and then increased again, having a regular variation of about ten years: the year 1844 was given as having a minimum variation of 6′.61 and the year 1848 as presenting a maximum variation of 11′.15.

Sabine† (March, 1852) in searching for periodical laws amongst the mean effects of the larger magnetic disturbances, found a simultaneous period of increase and decrease both at Hobarton and Toronto, on opposite sides of the globe; the minimum effect was in 1843, and the maximum effect in 1848, according therefore almost exactly with Lamont's observations at Munich. But, besides that, he pointed out the extraordinary circumstance that this similar variation of the daily magnetic declination is the same in length of period as that discovered by M. Schwabe for the solar spots; and still more, that the maxima and minima of these two most different phenomena coincide; for 1843 presents the least diurnal variation and the smallest number of solar spots, and 1848 the largest magnetic variation and the greatest number of solar obscurations. He has also observed that the same period of increase and decrease exists with the same epochs in the diurnal variation of the magnetic inclination of the earth's magnetic force in both hemispheres. The phenomenon is general both as regards all the magnetic elements, and in parts of the globe most distant from each other.

Gautier appears to have been struck with the same coincidence; but did not publish his idea until July 1852.‡ Wolf of Berne, who has sought far into the history of the sun spots, had the same thought, publishing it first at the end of July or beginning of August, 1852. § He endeavours to trace the general condition of the spots from the year 1600, and concludes that the true length of the period is 11.11 years. As it is impossible to conceive such a coincidence in the length of the period and the time of the maxima and minima of these two greatly differing phenomena, without believing in some relation of them to a common cause; so, the observation of such a coincidence at this moment ought to urge us more than ever into an earnest and vigorous investigation of the true and intimate nature of magnetism; by means of which we now have hopes of touching in a new direction, not merely this remarkable force of the earth, but even the like powers of the sun itself.

[M. F.]

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* Poggendorff, Annalen, LXXXIV. p. 572.

† Philosophical Transactions, 1852, page 103.

‡ Bibliothèque Universelle, 1852, XX. 189.

§ Proceedings of Natural Society of Berne, Nos. 245—247.

## WEEKLY EVENING MEETING,

Friday, Jan. 28.

W. R. Grove, Esq., M.A., F.R.S., Vice-President, in the Chair.

Professor Williamson,

### *On Gerhardt's discovery of Anhydrous Organic Acids.*

The discovery by M. Gerhardt of a number of anhydrous organic acids has thrown so much light on one of the most important questions of chemical philosophy, that it constitutes one of the most remarkable illustrations of the manner in which the rich materials of organic chemistry may be brought to bear on the explanation of the phenomena of chemical action and the laws of chemical combination.

It is not unworthy of remark, that the bodies prepared by Gerhardt had for some years past been supposed to exist ready formed in combination with water and other bases, and that the chief objection to that supposition was founded on the circumstance of their never having been separated from such combination, and presented in an isolated form. In fact Gerhardt has supplied the very link in the chain, which was expected to constitute evidence for a familiar theory of the constitution of salts. But the process by which the result was attained is even more important than the result itself, and has led to our drawing from that result a conclusion different from that which was generally expected. Chemistry aims at discovering the nature of that action by which substances of opposite properties undergo those remarkable changes which we call chemical combination; and it naturally follows from this view of its objects, that chemical science is more advanced by the discovery of a new *process* than by the discovery of a new *substance;* and its theories are more immediately affected by the nature of a process of change than by any physical fact, such as the existence of a peculiar body or class of bodies. Thus it is that the method of isolating the anhydrous organic acids, has afforded evidence of a new view of the constitution of acids and salts.

A few words may serve to give an idea of the previous state of the question.

Compounds of oxygen-acids were supposed to consist of the anhydrous acid united with an oxide. Thus hydrated sulphuric acid was represented as containing the anhydrous group $S\,O_3$ plus an atom of water $H_2O$; and in the saturation of this hydrated

acid by a base such as potash, it was conceived that this oxide replaced the water. The existence of anhydrous sulphuric acid in an isolated state, and the fact that it so readily combines with water, was urged as an argument in favour of this theory; and the same holds good with phosphoric, carbonic, sulphurous, lactic, nitrous, and even (according to the recent discovery of Dessaignes) nitric acid.

However simple this view might appear and however satisfactory it might be in explaining those cases of combination for which it was specially intended, chemists soon became acquainted with bodies perfectly analogous in their general properties to the oxygen-acids, and producing by their action upon bases similar effects, but which, from the fact of their containing no oxygen, could not possibly be conceived as made up of water and an anhydrous-acid. For instance, hydrochloric acid was proved, both analytically and synthetically, to be composed of nothing but chlorine and hydrogen; and when it combines with potash, the hydrogen is found to leave the chlorine, whilst potassium takes its place.

Being desirous of simplifying as far as possible their views of these phenomena, and of extending the same explanation to all like cases, certain chemists were led to imagine a new mode of representing the constitution and reactions of oxygen-acids, which had the advantage of connecting the two classes of analogous reactions by the same theory. This consisted in conceiving, that in the formation of a hydrated acid, a compound radical is produced in combination with hydrogen; so that hydrated sulphuric acid is the hydrogen-compound of $SO_4$, in the same way as hydrochloric acid is the hydrogen-compound of chlorine. There were many arguments in favour of this view, amongst which the most prominent was derived from the fact, that when a salt of the one class, as chloride of potassium, decomposes a salt of the other, as sulphate of silver, the result is exactly in conformity with what must occur on the supposition of the compound radical; and in like manner, the electrolytic decomposition of a sulphate moves the group $SO_4$ to the positive pole, where it either combines with a metal or undergoes decomposition.

One of the strongest arguments against the view that the oxygen-acids contain water, is afforded by the results of recent researches (especially of MM. Laurent and Gerhardt) on the atomic weight of acids. Those chemists have rendered more definite and exact than they had been before, our ideas on the distinctions between monobasic, bibasic, and tribasic acids, and have clearly established that the correct expression of the atom of nitric acid must be such as contains half as much hydrogen as is contained in one atom of water (inasmuch as water is bibasic, and nitric acid monobasic). Of course this proportion may be as well established

by doubling the atomic weight of water as by halving that of hydrated nitric acid; but either way it is clear that hydrated nitric acid cannot *contain* water.

Such was the position of the question, when an English chemist proved that the formation of ether from alcohol (which was considered chemically as the hydrate of ether,) does not consist in a separation of two already formed compounds, but in a substitution of hydrogen by the organic radical ethyl. A similar fact M. Gerhardt has proved respecting a great number of organic acids, by preparing bodies which stand to them in the same relation as ether does to alcohol.

The researches of M. Cahours had led to the discovery of a series of bodies necessary for Gerhardt's process. These were obtained by the action of pentachloride of phosphorus on various hydrated organic acids, and consisted of chlorine combined with the oxygenized radical of the acid. Thus from benzoic acid was prepared the chloride of benzoil, $C_7\ H_5\ O\ Cl$, and the corresponding bodies, from cuminic, cinnamic, and various other acids. Gerhardt has since made by the same process the body $C_2\ H_3\ O\ Cl$, which is the chloride of the radical of acetic acid, called *othyl*. Now, on bringing any one of these chlorides in contact with the potassium-salt of the corresponding acid, the chemical force of combination between chlorine and potassium induced the decomposition.

These results can be most simply stated in the form adopted by M. Gerhardt the discoverer, which consists in comparing the composition of these bodies with that of water, from which they are formed by the substitution of one or both atoms of hydrogen by organic radicals.

Thus water being represented by the formula $\begin{matrix} H \\ H \end{matrix} O$, acetic acid is formed from it by the action of chloride of othyl $C_2\ H_3\ O\ Cl$, which forms $\begin{matrix} C_2\ H_3\ O \\ H \end{matrix} O + H\ Cl$ *i. e.* hydrated acetic acid and hydrochloric acid. If a second atom of chloride of othyl is made to act upon this acetic acid, or better upon the acetate of potash $\begin{matrix} C_2\ H_3\ O \\ K \end{matrix} O$, we get, besides chloride of potassium, a compound $\begin{matrix} C_2\ H_3\ O \\ C_2\ H_3\ O \end{matrix} O$ which when compared to the original type, may be considered as water having both its atoms of hydrogen replaced by the radical othyl, $C_2\ H_3\ O$. This compound is the anhydrous acetic acid which might be called the acetate of othyl, inasmuch as that radical has, in the formation of the compound, taken the place of the basic potassium in the acetate of potash.

In like manner, the anhydrous benzoic acid $\begin{matrix} C_7\ H_5\ O \\ C_7\ H_5\ O \end{matrix} O$ was made

by the action of the chloride of benzoil $C_3\ H_5\ O\,Cl$ on the benzoate of potash. It is a crystalline body, perfectly neutral to test paper, scarcely soluble in water, readily soluble in alcohol and ether. On continued boiling with water, it is converted into hydrated benzoic acid, one atom of the anhydride with one atom of water forming two atoms of the hydrated acid by an interchange of hydrogen and benzoil. Besides several of these anhydrous acids, Gerhardt has prepared some intermediate acids, analogous to the intermediate ethers, by combining two different radicals in the same group. Thus chloride of benzoil with cuminate of potash $\begin{matrix} C_{10}\ H_{11}\ O \\ K \end{matrix}\ O$ formed cuminate of benzoil or benzocuminic acid $\begin{matrix} C_{10}\ H_{11}\ O \\ C_7\ H_5\ O \end{matrix}\ O$; and in like manner, several other intermediate acids were prepared.

In conclusion, to this very brief exposition of this important series of discoveries, the Lecturer alluded to a feature of the development of the human mind in scientific research, which is strikingly illustrated by the substance and form of these results, and of which instances are probably to be found in the history of many others. The explanation of the above reactions consists in a combination of two modes of reasoning, which were developed by different schools, and for many years were used independently of one another. Gerhardt, to whose researches and writings some important steps in the doctrine of types are owing, formerly believed the truths which he saw from that point of view to be incompatible with the idea of radicals, but he now joins those chemists who find in each of these notions a necessary and most natural complement to the other.

May we not hope that such may be the result in other cases of difference of opinion on scientific questions, which the progress of knowledge will shew to have been owing to the incompleteness and one-sidedness of each view, rather than to any thing absolutely erroneous in either?

[A. W. W.]

## WEEKLY EVENING MEETING,

Friday, February 4.

W. R. Grove, Esq. M.A. F.R.S. Vice-President, in the Chair.

G. B. Airy, Esq. F.R.S. Astronomer Royal.

*On the results of recent calculations on the Eclipse of Thales and Eclipses connected with it.*

The Lecturer commenced by remarking that he should not have thought the calculations connected with any other eclipse a subject worthy of his audience. The eclipse commonly called that of Thales is however one of extraordinary interest. It refers to a point of time which connects in a remarkable way the history of Asia Minor and the Greek colonies settled there with the history of the great Eastern empires. Its precise date has been for a long time a subject of discussion among the ablest astronomical computers and chronologers. It shews in a remarkable degree the power of astronomy; for it is no small thing that we are able to go back so many centuries and confidently to describe a phænomenon which then occurred, almost to its minutest features. But it shews also the weakness of astronomy. It requires the combination of theory and observation, with a full sense of the possible inaccuracies of both, and with an endeavour by the use of each to correct the failings of the other. It requires general criticism, history, tradition, and a careful examination of geographical and military circumstances. But when all these aids are properly brought to bear upon it, a conclusion is obtained upon which there appears to be no room for further doubt.

In the last century, the computations, or rather the assumptions, of distant eclipses, were extremely vague. The theory of the moon's motion, as applicable to distant eclipses, was imperfect; and it would almost seem that computers, under a sense of this imperfection, felt themselves free to interpret the calculations as loosely as they might find convenient. Eclipses were adopted by them, as corresponding to historical accounts, which did not represent the physical phænomena when visible: some were even taken which occurred before sunrise or after sunset at the places of observation.

The great step made in theory, in reference to these inquiries, was the discovery made by Laplace near the end of the last century, of the secular change in the moon's mean motion in longitude (accompanied by similar changes in the motion of the perigee and the node). In explanation of this, the Lecturer pointed out that the force which acts

upon the moon tending to draw it towards the earth is not simply the attraction of the earth, but consists of that attraction diminished by a disturbing force which is produced by the sun's attraction. The sun sometimes attracts the moon towards the earth or the earth towards the moon, sometimes it produces the opposite effect; but on the whole it tends to pull the moon away from the earth. And this diminution of the earth's attraction is greater as the sun is nearer; and therefore, in an elliptic orbit such as the earth describes about the sun (or such as the sun *appears* to describe about the earth), the diminution of the earth's attraction is greater when the earth is nearest to the sun than when the earth is farthest from the sun. It might be supposed that one of these effects exceeds that which would happen when the earth is at its mean distance from the sun, as much as the other falls short of it; but in reality the excess is greater than the deficiency, and therefore the more excentric the earth's orbit is, the greater is this disturbing force. So long as these circumstances remain the same, the magnitude of the moon's orbit will not be sensibly altered. But the fact is, that, in consequence of the perturbations produced by the planets, though the earth's mean distance from the sun remains unaltered from age to age, yet the excentricity of its orbit is diminishing from age to age; the sun's disturbing force is therefore diminishing from age to age: and the real force which acts upon the moon as tending to draw it towards the earth is therefore increasing from age to age; and, from age to age, the moon approaches a little nearer to the earth and performs her revolutions a little quicker. This effect is extremely small. Between one lunation and the next (taken one with another) the moon's distance from the earth is diminished by about $\frac{1}{14}$ of an inch; it would seem at first that this could produce no discoverable effect in the moon's motion: but one of the most wonderful things in the application of the laws of mechanics generally, and the law of gravitation in particular (where the magnitude of the force varies with the variation of distance), is, that the effect of a variation of a small fraction of an inch is as certain, in proportion to its magnitude, as that of a thousand miles. Still the effect produced in the moon's apparent motion is very small: in a century it amounts to only ten seconds; an angle which, when expressed in the usual way by the breadth of a known object as seen at a known distance, is less than the angle subtended by the human hand as seen at the distance of a mile. Yet in the course of twenty-four centuries the effect of this becomes so important as, in the case of eclipses, completely to change the face of the heavens; an eclipse might happen in Asia or Africa which, but for this consideration, we might expect to occur at that time in America.

Shortly after the discovery of this secular change, the French lunar tables (Bürg's) were constructed, the first which introduced this element. The late Mr. Francis Baily soon made use of these in an investigation of the date of the eclipse of Thales, which deserves to be

ranked among the most valuable that has been directed to that subject. The historical account of the eclipse is, that the Medes attacked the Lydians, and that a war continued several years, until at length, when the two armies were preparing for battle, the day suddenly became night (an event which Thales is said to have predicted), and both parties were so much alarmed that they made peace at once. Mr. Baily in the first place pointed out, from a collation of the best accounts of total and annular and other partial eclipses, that nothing but a total eclipse could produce such a striking effect and that a total eclipse could do it. Mr. Baily afterwards saw the total eclipse of 1842, but he saw it from the window of a house: the Lecturer, who had seen the total eclipses of 1842 and 1851, in each case from the top of a hill and in command of the open country, wished much that Mr. Baily could so have seen it, when he could not have failed to be reminded of his former assertions with regard to the eclipse of Thales: the phænomenon in fact is one of the most terrible that man can witness, and no degree of partial eclipses gives any idea of its horror. Mr. Baily then, using Bürg's tables, computed all the eclipses which could by possibility be visible in Asia Minor through a period of time exceeding that to which the eclipse of Thales is limited by chronological considerations, and found that only the eclipse of B. C. 610, September 30, could be total; and that the track of its shadow would pass across the mouth of the river Halys. He accordingly fixed upon that as the true date. But he then made a calculation which threw great doubt upon the result. Upon using the same tables to compute the eclipse of Agathocles (to be described shortly) he found that the track of the shadow would be nearly 200 miles in error; and, with a degree of good faith which was characteristic of him, he at once avowed his belief that if the elements of the tables were so altered as to make the eclipse of Agathocles possible, the eclipse of B. C. 610 could no longer be shewn to be total in or near Asia Minor. He expressed his confidence however that no other eclipse could, under any possible change of the tables, have been total in Asia Minor. Mr. Baily's conduct in this avowal was favorably contrasted with that of a German astronomer, Oltmanns; who, in one paper, using the same tables as Baily, fixed upon the same date as Baily for the eclipse of Thales; and in another paper, after alteration of the elements, shewed that the eclipse of Agathocles was possible; but, although he then alluded to his own calculations of the eclipse of Thales, had not the courage to announce that his former conclusions must now be considered to be unfounded.

The Lecturer then proceeded to explain how it happens that there exists such a connexion between two eclipses nearly 300 years apart, that the errors of calculation of one can have any influence upon the other. He explained that the moon's orbit is inclined to the sun's apparent orbit round the earth, but not always in the same direction, the line of nodes (or the intersection of the planes of the two orbits)

revolving so as to complete a revolution in about 19½ years; and that an eclipse of the sun can happen only when the line of nodes is turned nearly towards the sun (as, in other cases, the shadow falls above or below the earth). If for a given day of the year, (when the sun is in one certain position), the moon is in that part of its orbit most nearly in the direction of the sun, the shadow of the moon will fall upon a certain point of the earth; but now if the place of the node be changed, the effect will be that of driving a wedge under the moon, and she will be thrown further north or south, and the shadow upon the earth will be thrown further north or south. Thus the place of the node will define the part of the earth on which the shadow will be thrown; and conversely, a knowledge of the part of the earth on which the shadow is thrown will give information on the place of the node. Thus the alteration of the lunar elements, which is necessary to throw the shadow further north in the eclipse of Agathocles, consists in an alteration of the place of the node (other elements being supposed moderately correct); and this requires an alteration in the annual motion of the node, reckoning backwards from the present time when the position of the node is well known; and applying the same annual correction by the rule of three backwards to the place of the node at an assumed time of the eclipse of Thales, the corrected place of the node at that time is found, and then the corrected track of the moon's shadow can be found.

Subsequently to the time of the calculations of Baily and Oltmanns, the improvements in astronomy have been very great. Many advances have been made in theory, and one of the secular changes (that of motion of perigee) has been greatly modified. The Greenwich Lunar Observations from 1750 to 1830 (which are the foundation of Lunar Astronomy) have been completely reduced, on one uniform plan. Improvements have been made in the details of construction, but still greater improvements in the principles, of astronomical instruments. Our knowledge, also, of the geography of the countries to which the eclipses before us have relation, is much more accurate and extensive than it was.

Still there remain causes of uncertainty in the results of any calculations made for such distant periods.

First, in the theory. No person who has not fairly entered into the details of the Lunar Theory can conceive the complexity of the algebraical expressions and the operations which occur in it. Besides the usual chances of error from mistake of figures and mistake of signs, there is the risk of mistake in the selection of some terms to the exclusion of others, and the possibility of positive error in the metaphysical reasoning which guides some of the operations. And we are driven at last to admit that what is sometimes called mathematical evidence is after all but moral evidence. And thus it has happened that the conclusions of different theorists on some very important points are by no means accordant.

Secondly, in the observations from which are determined the elements that are to be combined with theory. Upon the same principle by which it was shewn that the track of shadow in one eclipse depends upon the track of shadow in another eclipse, it will be easily seen that the track of shadow in a distant eclipse will depend upon the observed elevation of the moon in the beginning of the modern period of comparatively accurate astronomy; (for that elevation determines the place of the node; and an error in the elevation produces an error in the computed place of the node for that time; and this exhibits an error in the annual motion of the node; and that error carried through the long period to a distant eclipse produces a very great error in the place of the node there, and consequently in the track of the shadow). If a ladder of centuries be constructed, each stave corresponding to a century, the extent of tolerably accurate and well-reduced observations of the moon (1750 to 1830) is represented by only $\frac{4}{5}$ of an interval of staves. Thus it appears that an error of two seconds in Bradley's observations (the angle which a finger-ring subtends at the distance of a mile, and which is smaller than can be perceived by the unassisted eye) would destroy our conclusions with regard to the distant eclipses in question. The fault in the principle of the Greenwich instrument used for observing the elevation of the moon (namely a quadrant, the use of which was for many years the bane of astronomy), and the slovenly way of using it in Bradley's time (no attention being given to the taking the elevation of the moon at the precise instant of her passing the meridian, though her elevation then changes rapidly) might well allow of this error. The Lecturer stated that both in the careful examination of the principles on which instruments are constructed, and in the rigorous attention to the proper rules for their use, it might be hoped that great improvement would be found in modern times.

In consequence of these causes of uncertainty, it becomes very desirable, in the investigation of the eclipse of Thales, to correct the elements of the moon's motions by some other well determined eclipse. Omitting the eclipses since the year 1200 A.D., and two in the second century B.C. which are somewhat discordant, there are two eclipses of peculiar value. One is the eclipse at the battle of Stiklastad at which Olaf king of Norway was killed, A.D 1030, August 31; in which the precise spot is known, and the precise position of the moon is known (the breadth of the shadow being very small, inasmuch as, when the eclipse commenced on the earth, it was annular). The only objection is, that if there is any uncertainty in the secular change of mean motions, the adjustment of the mean motions to represent the eclipse of Stiklastad will still leave a large uncertainty on an eclipse about 1600 years before it. Using the illustration of the ladder of centuries, it is like fixing the ladder at the bottom and at a point at one third of its height, which fasten-

ing, if the ladder is bent in some uncertain degree, still leaves great uncertainty in the place of its top. The other eclipse is that of Agathocles, B.C. 310, August 15, which will leave little uncertainty of that kind, if we can but determine its exact place upon the earth.

Agathocles, the Lecturer stated, being blockaded by the Carthaginians in Syracuse, placed men on board a fleet, ready to escape on the first opportunity; the approach of a provision-fleet drew off the Carthaginian ships, and Agathocles burst out of the harbour, and was pursued by the Carthaginians, but escaped. The next morning there was an eclipse of the sun which was evidently total. After six days he landed in the Carthaginian territories at a place called the Quarries, and, traversing their provinces, reduced the citizens of Carthage to the utmost difficulty, (in their terror they sacrificed 500 children to their god Kronos). The Lecturer acknowledged his obligations to Capt. W. H. Smyth, R.N. who had called his attention to the enormous quarries at Alhowareah (Aquilaria) under Cape Bon, from which Utica and Carthage were built; which place appears to have been used by the Romans as a landing-place from Sicily; and which the Lecturer adopted without doubt as the landing-place of Agathocles. He then stated that from J. W. Bosanquet Esq., he had received the suggestion that Agathocles might have passed the Strait of Messina; and that gentleman had pointed out the passages in the historical accounts which indicated the belief of the sailors that they were going either to Italy or to Sardinia. The Lecturer stated that, on minute examination, he had found that only the city of Gela remained in alliance with Syracuse, and the provision-fleet must have come from Gela, and must have approached Syracuse from the south, and from this it followed that Agathocles must have escaped to the north. This brings the probable position of Agathocles at the time of the eclipse near to Messina; if it were still supposed (as had been formerly supposed) that he sailed to the south, his position would probably have been near to Cape Passaro. The Lecturer explained the small corrections which must be made in the Greenwich determination of the place of the moon's node to satisfy these two conditions: and these were then taken as bases for the investigations connected with the eclipse of Thales.

The armies which were confronted at the time of the eclipse of Thales were evidently large armies (from the circumstances that they were commanded by the kings in person, who were ready to make a treaty on the spot, and that their principal allies, Syennesis and Labynetus, were present). And the principal question to be answered is, where such armies were likely to march. The Lecturer called attention to the general form of Mount Taurus and Anti-taurus (as one part is sometimes called), ranging from the mountains in the south of Asia Minor, in a general north-eastern direction, till they joined the mountains about Trebizond

and Erzerum; and stated that, according to the best information that he could obtain, (in which he had been materially assisted by W. J. Hamilton, Esq. and M. Pierre Tchihacheff) the following were the principal roads through them. On the north coast there is one, of which the difficulties were well known from the retreat of the ten thousand Greeks. From Erzerum there are two roads towards Siwah (Sebaste) and Kaisarieh (the Cappadocian Cæsarea), rugged, and passing through barren countries. There is one road from Kaisarieh falling on a branch of the Euphrates, which flows by Malatieh (Melitene); a rugged road parallel to it from Guroun; and finally, the road which is the best of all, descending from the southern mountains into the plain of Tarsus and Adana, then skirting the sea by Issus to Antioch. The Lecturer stated that on examining history he found no instance of an easterly or westerly march through the northern mountains: he had found one march of an army (under the Byzantine emperor Heraclius) from Trebizond to the south, which army however returned by Issus: one march by Melitene, where the last great battle of Chosroes Nushirvan with the Byzantine armies was fought: but, from the time of the younger Cyrus and Alexander, the marches by Issus are very numerous. Some of these lines of march are evidently very much curved out of their straight direction in order to take advantage of the pass of Issus: thus Alexander marched thither from Angora (Ancyra): Valerian entered by Issus to attack Sapor: Sapor, when in Armenia, and on his way to attack Cæsarea, marched by Issus: Julian in return invaded Persia by the same road. From these circumstances it appeared most probable that the Medes entered by Issus to attack the Lydians, and that the battle-field would probably be included in the polygon whose angles are Issus, Melitene, Ancyra, Sardes, and Iconium.

The Lecturer then shewed what would be the track of the shadow in the eclipse of B. C. 585, May 28, either on the supposition that the place of the Moon's node was that given by the Greenwich observations, or on the supposition that the motion of the node was so corrected as to make the shadow in the eclipse of Agathocles pass centrally over the assumed southern position of Agathocles, or over the assumed northern position of Agathocles. The uncorrected Greenwich track, and the track over Asia Minor corresponding to a central eclipse on the southern position of Agathocles, though not inadmissible, are too far south to be accepted as probable; but the track over Asia Minor, corresponding to the elements which give a central or nearly central eclipse for the northern position of Agathocles (near the strait of Messina), would certainly pass over any probable position of the battle-field.

The conclusion as to the general fitness of the eclipse of B. C. 585 for representing the circumstances of the eclipse of Thales, by inference from modern elements of calculation, was first published by Mr. Hind in the Athenæum.

The Lecturer then stated that he had examined in greater or less detail every eclipse from B. C. 630 to B. C. 580, and that no other eclipse could pass over Asia Minor. That selected by Messrs. Baily and Oltmanns, it was now shewn, passed to the north of the sea of Azof.

In concluding this astronomical discussion, the Lecturer expressed his opinion that the date B. C. 585 was now established for the eclipse of Thales beyond the possibility of a doubt.

The Lecturer then alluded to the tradition preserved by Sir John Malcolm from the poetical History of Persia, that Kai Kaoos (whom Sir John Malcolm considers to be the same as Cyaxares or Astyages, or possibly to represent both), having marched on a military expedition into Mazenderam, himself and his army were struck with sudden blindness; and that this had been foretold by a magician. Sir John Malcolm considered, and it appears most probable, that this is the record of a total eclipse of the sun; but no total eclipse near this time passed over Mazenderam. The Lecturer conceived therefore that it might refer to the eclipse of Thales, though with a strange perversion of the name of the province. Such perversions however occur in the Persian poetical history with regard to other names, which there is reason to believe are correctly given by the Greeks. The name Xerxes, for instance, has been found by Colonel Rawlinson in the Behistun inscriptions under the form *Khshayarsha*, of which the Greek Xerxes was probably a fair oral representation; whereas the name preserved in the poetical history is Isfundear. These confusions however are incidental to poetical history: thus if the Henriade of Voltaire should remain as the only history of the times to which it relates, the name of the king who preceded Henri IV. would go down as Valois, instead of Henri III. [G. B. A.]

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## GENERAL MONTHLY MEETING,

Monday, February 7.

William Pole, Esq., M.A, F.R.S., Treasurer and Vice-President, in the Chair.

Thomas W. Allies, Esq.
J. Bell Brooking, Esq.
John Forster, Esq., F.L.S.
John Henderson, Esq.
Thomson Hankey, Esq.

were duly *elected* Members of the Royal Institution.

**The following PRESENTS were announced, and the thanks of the Members returned for the same; —**

FROM

*Actuaries, Institute of* — The Assurance Magazine, No. 10. 8vo. 1853.
*Allies, Jabez, Esq., F.S.A., (the Author)* — The Ancient British, Roman, and Saxon Antiquities and Folk-Lore of Worcestershire. 8vo. 1852.
*Art-Union of London* — Sixteenth Annual Report. 8vo. 1852.
Art-Union Almanack for 1853.
*Asiatic Society of Bengal* — Journal, No. 229. 8vo. 1852.
*Astronomical Society (Royal)* — Monthly Notices, Vol. XIII. No. 1. 8vo. 1852.
*Athenæum Club* — List of Members. 8vo. 1852.
*Bell, Jacob, Esq. (the Editor)* — The Pharmaceutical Journal for Jan. and Feb. 1853. 8vo.
*Bevan, C. W., Esq.* — The Literary and Scientific Register and Almanack for 1853. 18mo. 1853.
*Bombay Geographical Society* — Transactions, Vol. X. 8vo. 1852.
*British Architects, Royal Institute of* — Proceedings, Dec. 1852, and Jan. 1853. 4to.
*Carpenter, W. B., M.D., F.R.S. (the Author)* — Principles of Human Physiology. 4th Edition. 8vo. 1853.
*Chemical Society* — Quarterly Journal, No. 20. 8vo. 1853.
*Civil Engineers, Institution of* — Proceedings, Dec. 1852, and Jan. 1853. 8vo.
*Cocks, Messrs. and Co.* — Cocks's Musical Miscellany, First Series. 4to. 1850-1. Second Series, Vol. I. Nos. 1-12. 4to. 1852-3.
*College of Chemistry (Royal)* — Table for the Comparison of the Centigrade, Reaumur, and Fahrenheit Thermometers, French and English Measures, &c. 8vo. 1853.
*Commissioners for the Exhibition of* 1851 — Second Report. 8vo. 1852. Report of the Juries. 8vo. 1853.
*Dennet, Charles F., Esq.* — Reply to the Strictures of Lord Mahon and others on the Mode of Editing the Writings of Washington, by Jared Sparks; with a Review of Lord Mahon's History, &c. 8vo. 1852.
Letter to Lord Mahon (in answer to his Letter); by Jared Sparks. 8vo. 1852.
Report to the Senate of the United States on Colt's Repeating Pistols. 8vo. 1851.
Pilot, and Wind and Current Charts of the North and South Atlantic Oceans, in 19 sheets; also Sailing Directions derived from the above Charts by Lieut. M. F. Maury, U. S. N. 4to. Washington, 1850.
Astronomical Observations during 1846, made at the National Observatory, Washington, under the direction of Lieut. M. F. Maury. Vol. II. 4to. 1851.
*East India Company, Hon.* — Report of the Commissioners for Post Office Enquiry, with Appendixes. Calcutta. 1851.
*Editors.* — The Athenæum for Nov. and Dec. 1852, and Jan. 1853. 1852. 4to.
The Medical Circular for Dec. 1852, and Jan. and Feb. 1853. 8vo.
The Practical Mechanic's Journal for Dec. 1852, Jan. and Feb. 1853. 4to.
*Faraday Professor, F.R.S., &c.* — Koninklijk-Nederlandsche Instituut van Wetenschappen :—
Verhandelingen der Eerste Klasse. Derde Reeks, V^e^. Deel. 4to. Amsterdam. 1852.
Tijdschrift der Eerste Klasse, V^e^. Deel. 8vo. Amsterdam. 1852.
Jaarboek van Wetenschappen, Letterkunde en Schoone Kunsten voor 1851, 8vo. Amsterdam, 1852.
Atti dell' Accademia Pontificia de' Nuovi Lincei, Anno V. Sessione I^a^. 4to. Roma. 1852.

Bulletin de la Classe Physico-Mathématique de l'Académie des Sciences de St. Petersbourg. Tome X. 4to. 1852.
Monatsbericht der Königl. Preuss. Akademie, Sept., Oct. und Nov. 1852. 8vo. Berlin.
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*Franklin Institute, Philadelphia* — Journal, Vol. XXIV. No. 3, 4, 5. 8vo. 1852.
*Geographical Society (Royal)* — Journal, Vol. XXII. 8vo. 1852.
*Godwin, George, Esq. F.R.S. (the Author)* — History in Ruins: a Series of Letters to a Lady embodying a Popular Sketch of the History of Architecture, &c. 16mo. 1853.
*Horticultural Society of London* — Journal, Vol. VIII. Part 1. 8vo. 1853.
*Leeds Philosophical and Literary Society* — Laws and Regulations. 8vo. 1841. Transactions, Vol. I. Part I. 8vo. 1837.
Annual Reports, 5th, 6th, 7th, 11th, 12th, 14th to 19th, and 21st to 32nd. 8vo. 1825-52.
Account of an Egyptian Mummy (presented by J. Blayds, Esq.) by W. Osburn, F.R.S.L. 8vo. 1828.
*Lovell, E. B. Esq. M.R.I. (the Editor)* — The Monthly Digest for Dec. 1852 and Jan. 1853. 8vo.
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*Moxon, Edward, Esq. M.R.I.* — Poems, by Thomas Hood. 16mo. 1852.
*M. M.* — Dirge for Wellington. 8vo. 1852.
*Novello, Messrs.* — Musical Times for Jan. and Feb. 1853. 4to.
*Parsons, P. M., Esq., C.E. (the Author)* — Proposed London Railway to afford direct Communication between the City and Westminster and all the Western Suburbs; and to unite all the Metropolitan Railways; and to provide them with a General Central Station. Illustrated with Plans. 8vo. 1853.
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*Price, Rev. Bartholomew, M.A., F.R.S. (the Author)* — Treatise on the Differential Calculus, and its Applications to Algebra and Geometry. 8vo. 1852.
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*Royal Society of London* — Transactions for 1852, Part I. 4to. 1852.
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Tijdschrift voor de Wis-en Natuurkundige Wetenschappen, Deel I. II. III. 8vo. 1848—50.
Jaarboek van Wetenschappen, Letterkunde en Schoone Kunsten voor 1847, 1848, 1849, 1850. 4 vol. 8vo. 1847—50.
Verslagen over het Patent verleend aan Dr. Scoffern voor een door hem uitgewonden Procédé van Suikerbereidung door Middel van Loodsuiker. 8vo. Amsterdam, 1852.
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*Statistical Society of London* — Journal, Vol. XV. Part 4. 8vo. 1852.

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Blumenlese aus den Schriften von B. Naubert. 2 vol. 16mo. 1829.

Weinrausch, Sammlung von Scherzen, u. s. w. 1837.

Gustav's Reise-Abentheuer mit einer alten Muse, von C. J. Oldendorp. 16mo. Leipzig, 1828.

Die Nacht in der Hölle. Ein Roman von F. Laun. 16mo. Berlin, 1825.

Humoristisch-satyrischer Volks-Kalender des Kladderadatsch für 1853. Herausgegeben von D. Kasisch. Vierter Jahrgang. Berlin, 1853.

Commercial Hints and Companion to the Counting-house, &c., By Thomas Smith; — also Treatise on Book-keeping; by the same. 12mo. 1837.

P. Virgilii Maronis Opus eximium per Paulum Malleolum Andelacensem iterata diligentiâ plane recognitum. 4to. Parrhisiis, 1498.

Hans Sachs ernstliche Trauerspiele, liebliche Schauspiele, u. s. w. bearbeitet und herausgegeben von Dr. J. G. Büsching. 3 vol. 8vo. Nürnberg, 1816-24.

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*Twining, Henry, Esq., M.R.I. (the Author)*—The Elements of Picturesque Scenery; or Studies of Nature made in Travel with a View to Improvement in Landscape-Painting. 8vo. 1853.

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Hebel's Allemannische Gedichte, 16mo. Aarau, 1827.

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## WEEKLY EVENING MEETING,

Friday, February 11.

THE DUKE OF NORTHUMBERLAND, K.G., F.R.S., President, in the Chair.

JOHN TYNDALL, ESQ., Ph. D., F.R.S.

*On the influence of Material Aggregation upon the manifestations of Force.*

THERE are no two words with which we are more familiar than *matter* and *force*. The system of the universe embraces two things,—an object acted upon, and an agent by which it is acted upon;—the object we call matter, and the agent we call force. Matter, in certain aspects, may be regarded as the vehicle of force; thus the luminiferous ether is the vehicle or medium by which the pulsations of the sun are transmitted to our organs of vision. Or to take a plainer case; if we set a number of billiard balls in a row and impart a shock to one end of the series, in the direction of its length, we know what takes place; the last ball will fly away, the intervening balls having served for the transmission of the shock from one end of the series to the other. Or we might refer to the conduction of heat. If, for example, it be required to transmit heat from the fire to a point at some distance from the fire, this may be effected by means of a conducting body — by the poker for instance: thrusting one end of the poker into the fire it becomes heated, the heat makes its way through the mass, and finally manifests itself at the other end. Let us endeavour to get a distinct idea of what we here call heat; let us first picture it to ourselves as an agent apart from the mass of the conductor, making its way among the particles of the latter, jumping from atom to atom, and thus converting them into a kind of stepping-stones to assist its progress. It is a probable conclusion, even had we not a single experiment to support it, that the mode of transmission must, in some measure, depend upon the manner in which those little molecular stepping-stones are arranged. But we need not confine ourselves to the material theory of heat. Assuming the hypothesis which is now gaining ground, that heat, instead of being an agent apart from ordinary matter, consists in a motion of the material particles; the conclusion is equally probable that the transmission of the motion must be influenced by the manner in which the particles are arranged. Does experimental science furnish us with any corroboration of this inference? It does. More than twenty years ago MM. De la Rive and De Candolle proved that heat is transmitted through wood with a velocity almost twice as great along the fibre as across it. This result has been recently expanded, and it has been proved that this substance possesses three

axes of calorific conduction; the first and greatest axis being parallel to the fibre; the second axis perpendicular to the fibre and to the ligneous layers; while the third axis, which marks the direction in which the greatest resistance is offered to the passage of the heat, is perpendicular to the fibre and parallel to the layers.

But it is the modification of the magnetic force by the peculiarities of aggregation, which forms the subject of the evening's lecture. What has been stated regarding heat applies with equal force to magnetism. The observed magnetic phenomena are of a composite character. The action of a magnetic mass is the resultant action of its molecules, and will be influenced by the manner in which they are aggregated. The fundamental phenomena of magnetism are too well known to render it necessary to dwell upon them for an instant. A small bar of iron was suspended in the magnetic field; it set its length parallel to the line joining the poles. Should we be justified from this experiment in concluding that a magnetic mass will always set its longest dimension axial? No. A second magnetic bar, equal in size to the former, was suspended between the poles; it set its length at right angles to the line joining the poles. Whence this deportment? We find the reason of it in the mechanical structure of the bar: it is composed of magnetic plates, transverse to its length: these plates set from pole to pole and hence the length of the bar equatorial. But let us proceed from this coarse experiment to one more delicate, where nature herself has imposed the conditions of aggregation. A plate taken from a mass of shale, picked up a few weeks ago in the coal district of Blackburn, was suspended between the poles; although strongly magnetic it set its longest dimension at right angles to the line joining the poles. This deportment was at once explained by reference to the structure of the mass: it also, though apparently compact, was composed of layers transverse to its length; these layers set from pole to pole and hence the length equatorial. Let us ascend to a case still more refined. A crystal of sulphate of nickel was suspended between the poles, and on exciting the magnet a certain determinate position was taken up by the crystal. The substance was magnetic, still its shortest dimension set from pole to pole. The crystal was removed from the magnetic field and the edge of a penknife placed along the line which set axial; a slight pressure split the crystal and disclosed two beautiful surfaces of cleavage. The crystal could in this way be cloven into an indefinite number of magnetic layers; these layers set from pole to pole and hence the longest dimension, which was perpendicular to the layers, equatorial. Comparing all these experiments,—ascending from the gross case where the laminæ were plates of iron stuck together by wax, to that in which they were crystalline, the inference appears unavoidable that the unanimity of deportment exhibited is the product of a common cause; and that the results are due to the peculiarities of material aggregation.

The beautiful researches of Plücker in this domain of science are well known. Plücker's first experiment was made with a plate of tourmaline. Suspended in the magnetic field with the axis of the crystal vertical, it set its length from pole to pole, like an ordinary magnetic body. Suspended with the axis of the horizontal, on exciting the magnet, Plücker found to his astonishment that the largest dimension set equatorial. Let us see whether we cannot obtain this deportment otherwise. Suspending the piece of shale already made use of, so that its laminæ were horizontal, on exciting the magnet the longest horizontal dimension of the plate set axial: moving the point of suspension 90° so that the laminæ were vertical, on exciting the magnet the length of the plate set equatorial. In the magnetic field the deportment of the crystal was perfectly undistinguishable from that of the shale. But it may be retorted that tourmaline possesses no such laminæ as those possessed by the shale: true — nor is it necessary that it should do so. A number of plates, bars, and disks, formed artificially from magnetic dust, exhibited a deportment precisely similar to the tournaline, — suspended from one point they set their lengths axial, suspended from another point the lengths set equatorial. Let us now turn to what may be called the complementary actions exhibited by diamagnetic bodies. A homogeneous diamagnetic bar sets its length equatorial. But bars were exhibited composed of transverse diamagnetic laminæ which set their lengths axial. This experiment is complementary to that of the shale, &c.; the magnetic laminæ set axial, the diamagnetic equatorial; and by attention to this the magnetic body is made to behave like a homogeneous diamagnetic body, and the diamagnetic body like a homogeneous magnetic body. Diamagnetic bars and disks were also examined, and a deportment precisely complementary to that of the magnetic bars and disks was exhibited. A magnetic disk set its thickness from pole to pole and consequently its horizontal diameter equatorial; a diamagnetic disk set its thickness equatorial and its horizontal diameter from pole to pole. Two bodies of the same exterior form and of the same colour, were suspended simultaneously in the fields of two electro-magnets, and both the latter were excited by the same current; the eye could detect no difference of deportment. Both bodies possessed the shape of calcareous spar, and both set the crystallographic axis equatorial. One body however was composed of wax, while the other was a true crystal. In the same way a crystal of carbonate of iron exhibited a deportment precisely the same as that of a model formed of magnetic dust. The explanation of these phenomena may be given in a few words. In the construction of the models, the magnetic or diamagnetic dust was formed into a kind of dough and pressed between two glass plates; the same process was applied to the wax; and it is a universal law, that in diamagnetic bodies the line along which the density of the mass has been increased by compression, sets equatorial,

and in magnetic bodies axial. A reference to this principle will instantly render plain all the experiments we have described. In those cases where the same artificial bar set at one time axial and at another time equatorial, the deportment depended on the circumstance whether the line of compression was vertical or horizontal. When vertical its directive power was annulled, and the action was determined by the exterior form of the body; but when horizontal its directive action came into play and determined the position of the mass. The magnetic bar, for example, suspended with its line of pressure vertical, set axial, but with its line of pressure horizontal, it set equatorial; for the pressure was exerted at right angles to its length. This action is so general that it is difficult to find a body so perfectly homogeneous as not to exhibit it in some degree. Ipecacuanha lozenges and Carlisle biscuits were suspended in the magnetic field and exhibited a most striking directive action. The materials in both cases were diamagnetic; but owing to the pressure exerted in their formation their largest horizontal dimensions set from pole to pole, the line of compression being equatorial.

Let us endeavour to arrive at the precise logical import of these experiments. Let us suppose that before ever a crystal had been suspended in the magnetic field, we were acquainted with the fact that a slight change of density in any direction is accompanied by such modifications of the magnetic force as those above described:—that we knew that flour, bran, soap, shale, magnetic dust, diamagnetic dust, &c., all exhibited this directive action,—that it is in fact a universal law of matter; and then let us imagine some fortunate experimenter hanging a crystal between the poles and observing a deportment in every respect similar. Would not the analogy of the case at once flash upon him? Would he not regard this deportment as a beautiful, but still special example of that all-pervading law with which he was previously acquainted. Would he not congratulate himself on the possibility thus opened to him of searching out the mysteries of crystalline structure, and rendering apparent to his mental eye the manner in which the molecules are aggregated together. He would never have assumed the existence of forces altogether new to account for the observed actions; much less would he have affirmed that they were wholly independent of magnetism or diamagnetism; for he would know beforehand that the modification of these forces by the peculiarities of aggregation was the exact thing calculated to produce the phenomena. But magne-crystallic action was discovered when its universality was unknown; and hence its discoverer was led to regard it as something unique. A great temptation lay in his way: years before, a magnet, now present, had twisted a ray of light, and thus suggested a connexion between light and magnetism. What wonder then if this unifying instinct, this yearning to find the mystic bond which unites these forces, this prediction of the human mind that all the forces of

nature are but branches of a common root,—what wonder, I say, if it jumped its bounds and cried "I have it!" too soon. For a long time the optic axis, and it alone, was chargeable with these phenomena,—phenomena which it was now hoped, there would be little difficulty in referring to their proper cause, and regarding as examples of the modification of force by the peculiarities of aggregation.

The Lecturer then pointed out the bearing of the described results upon the problem of the diurnal range of the magnetic needle. Professor Faraday had referred the matter to the modification of atmospheric magnetism by the sun's rays. That an effect was produced here could not for a moment be doubted, but the precise extent of this effect was still an open question. The discovery of a decimal period by Lamont threw a great difficulty in the way of any theory which would refer the diurnal range to thermic action; and the difficulty was greatly increased by the observation of Col. Sabine, who connected Lamont's discovery with that of Schwabe regarding the solar spots. But whatever the result of future enquiries as to the direct magnetism of the sun may be, no theory which proposes to exhaust the subject can afford to omit the mediate operation of the sun by his heat; not however confining it to the atmosphere, but extending it also to the earth's solid crust. Let us look once more to our experiments. The line of greatest density is that of strongest magnetic power. The body operated upon by the magnet is itself a magnet, and it is an experimental fact, that it is a stronger magnet along the line of greater density than along any other line. If instead of increasing the density in one direction we increase it in all directions, we thereby augment the general magnetic power of the body. Anything therefore which tends to increase density increases magnetic power; and whatever diminishes density diminishes magnetic power also. Knowing this, the conclusion is inevitable, that the local action of the sun upon the earth's crust must influence, in some degree, the resultant effect. The action here meant is wholly different from that hitherto speculated on, and which had reference to the generation of thermo-electric currents which affect the needle. The simple mechanical change of density is what is meant. It is a true cause, and no complete theory can omit taking it into account.

The Lecturer then proceeded to remark on the influence of geologic changes upon the earth as a magnet, and concluded as follows:

"This evening's discourse is, in some measure, connected with this locality; and thinking thus, I am led to enquire wherein the true value of a scientific discovery consists? Not in its immediate results alone, but in the prospect which it opens to intellectual activity, in the hopes which it excites, in the vigour which it awakens. The discovery which led to the results brought before you to-night was of this character. *That* magnet was the physical birth-place of these results; and if they possess any value they are to be regarded as the returning crumbs of that bread which in 1846

was cast so liberally upon the waters. I rejoice, Ladies and Gentlemen, in the opportunity here afforded me of offering my tribute to he greatest worker of the age, and of laying some of the blossoms of that prolific tree which he planted, at the feet of the great discoverer of diamagnetism."

[J. T.]

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## WEEKLY EVENING MEETING,

Friday, February 18.

The Duke of Northumberland, K.G., F.R.S., President, in the Chair.

G. G. Stokes, M.A., F.R.S., Lucasian Professor, Cambridge.

*On the Change of Refrangibility of Light, and the exhibition thereby of the Chemical Rays.*

Before proceeding to the more immediate subject of the Lecture, it was necessary to refer to certain discoveries of Sir John Herschel and Sir David Brewster, more especially as it was the discovery by the former of these philosophers of the epipolic dispersion of light, and of the peculiar analysis of light which accompanies the phenomenon, that led to the researches respecting the change of refrangibility.

When a weak acid solution of quinine is prepared, by dissolving, suppose, one part of the commercial disulphate in 200 parts of water acidulated with sulphuric acid, a fluid is obtained which appears colourless and transparent when viewed by transmitted light, but which exhibits nevertheless in certain aspects a peculiar sky-blue colour. This colour of course had frequently been noticed; but it is to Sir John Herschel that we owe the first analysis of the phenomenon.* He found that the blue light emanates in all directions from a very thin stratum of fluid adjacent to the surface, (whether it be the free surface or the surface of contact of the fluid with the containing glass vessel,) by which the incident rays enter the fluid. His experiments clearly shew that what here takes place is not a mere *subdivision* of light into a portion which is dispersed and a portion which passes on, but an actual *analysis*. For after the rays have once passed through the stratum from which the blue dispersed light comes, they are deprived of the power of producing the

* Philosophical Transactions for 1845, p. 143.

same effect; that is, they do not exhibit any blue stratum when they are incident a second time on a solution of quinine. To express the modification which the transmitted light had undergone, the further nature of which did not at the time appear, Sir John Herschel made use of the term "epipolized."

Sir David Brewster had several years before discovered a remarkable phenomenon in an alcoholic solution of the green colouring matter of leaves, or, as it is called by chemists, chlorophyll. This fluid when of moderate strength and viewed across a moderate thickness is of a fine emerald green colour; but Sir David Brewster found that when a bright pencil of rays, formed by condensing the sun's light by a lens, was admitted into the fluid, the path of the rays was marked by a *bright beam* of a *blood red colour*.* This singular phenomenon he has designated *internal dispersion*. He supposed it to be due to suspended particles which reflected a red light, and conceived that it might be imitated by a fluid holding in suspension an excessively fine coloured precipitate. A similar phenomenon was observed by him in a great many other solutions, and in some solids; and in a paper read before the Royal Society of Edinburgh in 1846 he has entered fully into the subject.† In consequence of Sir John Herschel's papers, which had just appeared, he was led to examine a solution of sulphate of quinine; and he concluded from his observations that the "epipolic" dispersion of light exhibited by this fluid was only a particular instance of internal dispersion, distinguished by the extraordinary rapidity with which the rays capable of dispersion were dispersed.

The Lecturer stated, that, having had his attention called some time ago to Sir John Herschel's papers, he had no sooner repeated some of the experiments than he felt an extreme interest in the phenomenon. The reality of the epipolic analysis of light was at once evident from the experiments; and he felt confident that certain theoretical views respecting the nature of light had only to be followed fearlessly into their legitimate consequences, in order to explain the real nature of epipolized light.

The exhibition of a richly coloured beam of light in a perfectly clear fluid, when the observation is conducted in the manner of Sir David Brewster, seemed to point to the dispersions exhibited by the solutions of quinine and chlorophyll as one and the same phenomenon. The latter fluid, as has been already stated, disperses light of a blood red colour. When the transmitted light is subjected to prismatic analysis, there is found a remarkably intense band of absorption in the red, besides certain other absorption bands, of less intensity, in other parts of the spectrum. Nothing at first seemed more likely than that, in consequence of some action of the ultimate molecules of the medium, the incident rays belonging to the absorp-

* Edinburgh Phil. Trans. Vol. XII. p. 542.

† Vol. XVI. Part 2, and Phil. Mag. June, 1848.

tion band in the red, withdrawn, as they certainly were, from the incident beam, were given out in all directions, instead of being absorbed in the manner usual in coloured media. It might be supposed that the incident vibrations of the luminiferous ether generated synchronous vibrations in the ultimate molecules, and were thereby exhausted, and that the molecules in turn became centres of disturbance to the ether. The general analogy between the phenomena exhibited by the solutions of chlorophyll and of quinine would lead to the expectation of absorption bands in the light transmitted by the latter. If these bands were but narrow, the light belonging to them might not be missed in the transmitted beam, unless it were specially looked for; and the beam might be thus "epipolized," without, to ordinary inspection, being changed in its properties in any other respect. But on subjecting the light to prismatic analysis, first with the naked eye, and then with a magnifying power, no absorption bands were perceived.

A little further reflection shewed that even the supposition of the existence of these bands would not alone account for the phenomenon. For the rays producing the dispersed light, (if we confine our attention to the thin stratum in which the main part of the dispersion takes place,) are exhausted by the time the incident light has traversed a stratum the fiftieth of an inch thick, or thereabouts, whereas the dispersed rays traverse the fluid with perfect freedom. This indicates *a difference of nature* between the blue-producing rays and the blue rays produced. Now, as the Lecturer stated, he felt very great confidence in the principle that the nature of light is completely defined by specifying its refrangibility and its state as to polarization. The difference of nature, then, indicated by the phenomenon, must be referred to a difference in one or other of these two respects. At first he took for granted that there could be no change of refrangibility. The refrangibility of light had hitherto been regarded as an attribute absolutely invariable.* To suppose that it had changed would, on the undulatory theory, be equivalent to supposing that periodic vibrations of one period could give rise to periodic vibrations of a different period, a supposition presenting no small mechanical difficulty. But the hypotheses which he was *obliged* to form on adopting the other alternative, namely, that the difference of nature had to do with the state of polarization, were so artificial as to constitute a theory which appeared utterly extravagant. He was thus led to contemplate the possibility of a change of refrangibility. No sooner had he dwelt

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* It is true that the phenomenon of phosphorescence is in a certain sense an exception; but the effect is in this case a work of time, which seems at once to remove it from all the ordinary phenomena of light, which, as far as sense can judge, take place instantaneously. It is true that there now appears a close analogy in many respects between true internal dispersion and phosphorescence. But while the nature of epipolized light remained yet unexplained, there was nothing in the former phenomenon to point to the latter.

in his mind on this supposition, than the mystery respecting the nature of epipolized light vanished; all the parts of the phenomenon fell naturally into their places. So simple did the whole explanation become, when once the fundamental hypothesis was admitted, that he could not help feeling strongly impressed that it would turn out to be true. Its truth or fallacy was a question easily to be decided by experiment; the experiments were performed, and resulted in its complete establishment.

The Lecturer then described what may be regarded as the fundamental experiment. A beam of sunlight was reflected horizontally through a vertical slit into a darkened room, and a pure spectrum was formed in the usual manner, namely, by transmitting the light through a prism at the distance of several feet from the slit, and then through a lens close to the prism. In the actual experiment, two or three prisms were used, to produce a greater angular separation of the colours. Instead of a screen, there was placed at the focus of the lens a vessel containing a solution of sulphate of quinine. It was found that the red, orange, &c., in fact, nearly the whole of the visible rays, passed through the fluid as if it had been mere water. But on arriving about the middle of the violet, the path of the rays within the fluid was marked by a sky-blue light, which emanated in all directions from the fluid, as if the medium had been self-luminous. This blue light continued throughout the region of the violet, and far beyond, in the region of the invisible rays. The posterior surface of the luminous portion of the fluid marked the distance to which the incident rays were able to penetrate into the medium before they were exhausted. This distance, which at first exceeded the diameter of the vessel, decreased with great rapidity, so that in the greater part of the invisible region it amounted to only a very small fraction of an inch. The fixed lines of the extreme violet, and of the more refrangible invisible rays, were exhibited by dark planes interrupting the dispersed light. When a small portion of the incident spectrum was isolated, by stopping the rest by a screen, and the corresponding beam of blue dispersed light was refracted sideways by a prism held to the eye, it was found to consist of light having various degrees of refrangibility, with colour corresponding, the more refrangible rays being more abundant than the less refrangible. The nature of epipolized light is now evident; it is nothing but light from which the highly refrangible invisible rays have been withdrawn by transmitting it through a solution of quinine, and does not differ from light from which those rays have been withdrawn by any other means.

The fundamental experiment, excepting that part of it which relates to the analysis of the dispersed light, was then exhibited by means of the powerful voltaic battery belonging to the Institution, which was applied to the combustion of metals. The rays emanating from the voltaic arc were applied to form a pure spectrum, which was received on a slab of glass coloured by peroxide of ura-

nium, a medium which possesses properties similar to those of a solution of sulphate of quinine in a still more eminent degree.

The difference of nature of the illumination produced by a change of refrangibility, or "true internal dispersion," from that due to the mere scattering of light, may be shown in a very instructive form by placing paper washed with sulphate of quinine, or a screen of similar properties, so as to receive a long narrow horizontal spectrum, and refracting this upwards by a prism held to the eye. Were the luminous band formed on the paper due merely to the scattering of the incident rays, it ought of course to be thrown obliquely upwards; whereas it is actually decomposed by the prism into two bands, one ascending obliquely, and consisting of the usual colours of the spectrum in their natural order, the other running horizontally, and extending far beyond the more refrangible end of the former. Whatever be the screen, the horizontal band is always situated below the oblique, since there appears to be no exception to the law, that when the refrangibility of light is changed in this manner it is *always lowered.*

The general appearance of some highly "sensitive" media in the invisible rays was then exhibited by means of the flame of sulphur burning in oxygen, a source of these rays which Dr. Faraday, to whose valuable assistance the Lecturer was much indebted, had in some preliminary trials found very efficacious. The chief media used were articles made of glass coloured by uranium, and solutions of quinine, of horse-chestnut bark, and of the seeds of the datura stramonium. A tall cylindrical jar filled with water showed nothing remarkable; but when a solution of horse-chestnut bark was poured in, the descending fluid was strongly luminous. The experiment was varied by means of white paper on which words had been written with a pretty strong solution of sulphate of quinine, an alcoholic solution of the seeds of the datura stramonium, and a purified aqueous solution of horse-chestnut bark. By gas-light the letters were invisible; but by the sulphur light, especially when it had been transmitted through a blue glass, which transmits a much larger proportion of the invisible than of the visible rays, the letters appeared luminous, on a comparatively dark ground. A glass vessel containing a thin sheet of a very weak solution of chromate of potash allowed the letters to be seen as well, or very nearly as well as before, when it was interposed between the eye and the paper; but when it was interposed between the flame and the paper the letters wholly disappeared,—the medium being opaque with respect to the rays which caused the letters to be luminous, but transparent with respect to the rays which they emitted.

It was then remarked what facilities are thus afforded for the study of the invisible rays. When a pure spectrum is once formed, it is as easy to determine the mode of absorption of an absorbing medium with respect to the invisible, as with respect to the visible rays. It is sufficient to interpose the medium in the path of the incident

rays, and to notice the effect. Again, the effect of various flames and other sources of light on solutions of quinine, and on similar media, indicates the richness or poverty of those sources with respect to the highly refrangible invisible rays. Thus, the flames of alcohol, of hydrogen, &c., of which the illuminating power is so feeble, were found to be very rich in invisible rays. This was still more the case with a small electric spark, while the spark from a Leyden jar was found to abound in rays of excessively high refrangibility. These highly refrangible rays were stopped by glass, but passed freely through quartz. These results, and others leading to the same conclusion, had induced the Lecturer to order a complete train of quartz. A considerable portion of this was finished before the end of last August, and was applied to the examination of the solar spectrum. A spectrum was then obtained extending beyond the visible spectrum, that is, beyond the extreme violet, to a distance at least double that of the formerly known chemical spectrum. This new region was filled with fixed lines like the regions previously known.

But a spectrum far surpassing this was obtained with the powerful electrical apparatus belonging to the Institution. The voltaic arc from metallic points furnished a spectrum no less than *six or eight times* as long as the visible spectrum. This was in fact the spectrum which had already been exhibited in connexion with the fundamental experiment. The prisms and lens which the Lecturer had been employing in forming the spectrum were actually made of quartz. The spectrum thus obtained was filled from end to end with bright bands. When a piece of glass was interposed in the path of the incident rays, the length of the spectrum was reduced to a small fraction of what it had been, all the more refracted part being cut away. A strong discharge of a Leyden jar had been found to give a spectrum at least as long as the former, but not, like it, consisting of nothing but isolated bright bands.

The Lecturer then explained the grounds on which he concluded that the end of the solar spectrum on the more refrangible side had actually been reached, no obstacle existing to the exhibition of rays still more refrangible if such were present. He stated also that during the winter, even when the sun shone clearly, it was not possible to see so far as before. As spring advanced he found the light continually improving, but still he was not able to see so far as he had seen at the end of August. It was plain that the earth's atmosphere was by no means transparent with respect to the most refrangible of the rays belonging to the solar spectrum.

In conclusion, there was exhibited the effect of the invisible rays coming from a succession of sparks from the prime conductor of a large electrifying machine, in illuminating a slab of glass coloured by uranium.

[G. G. S.]

## WEEKLY EVENING MEETING,

Friday, Feb. 25.

THE DUKE OF NORTHUMBERLAND, K.G., F.R.S., President, in the Chair.

JOHN WILSON, ESQ., F. R. S. E. &c.

*On Ploughs and Ploughing, Ancient and Modern.*

WITHOUT attempting to discuss the general question of scientific farming, on one point, at all events, all will agree, that the application of science to the improvement of machines and implements has been productive of great benefit to agriculture. Just now two circumstances in particular combine to affect the farmer's calling,—the competition of foreign produce in our markets and the diminishing supply of labour, due to emigration. To meet these successfully, production must be increased, and labour economised. These ends must be obtained either by the perfection of present processes or the substitution of others, for which the application of improved machines and implements offers the readiest means.

The plough was selected as the subject of the Lecture, firstly, because it is commonly recognized as the symbol of agriculture,—and secondly, because during the long period of its history it has, until quite recently, undergone fewer changes than most other implements of such universal use.

The object of agriculture is the conversion of mineral into organized matter, through the agency of the plants which she cultivates. The soil is the factory in which these changes principally take place;—and one of the conditions necessary is contact with the atmosphere. To effect this, mechanical means are needed to open up and divide the soil; and the plough was soon found to be a more efficient tool than either the pick or the spade, which were limited to manual labour.

Ploughs are mentioned in the early pages of our sacred history; indeed we have there described the skeleton upon which all ploughs, past and present, have been framed. The ancient Greeks and Romans paid great attention to farming, and especially to implements and their application. The plough, then as now, occupied a prominent place, and much practical information in respect to its uses has been handed down to us. Of the Greeks, the principal writers on agricultural matters, are Hesiod, Xenophon, Homer, Theocritus, and Theophrastus. The Roman authors are more numerous and their works better known; amongst them we may cite Cato, Virgil, Columella, Varro, Palladius, and Pliny. Many of their precepts are

valuable, and would compare very successfully with the practice of the present day. They held it to be bad farming to plough when the ground was wet, "*Lutosam terram ne tangito.*" Another maxim was never to plough with an unequal furrow, "*Sulco vario ne ares,*"— and a third was never to plough with a crooked furrow,— he who did so was said to prevaricate, "*Arator nisi incurvus prævaricatur.*" This expression was afterwards used in the forum, and the same meaning attached to it as in the present day. Let these maxims be posted in our market places, and no farmers who read would gainsay them; and yet how often do we see them disregarded in our fields.

Oxen were generally used, and *always harnessed two abreast*, and the quantity of work done in a yoking was from 1 jugerum (= .618 of an acre) to $1\frac{1}{2}$ jugerum. Pliny mentions having seen in Egypt ploughs drawn by cows, their calves skipping by their sides, and in more than one instance a team composed of an ass and an old woman harnessed together. The Roman plough was minutely described by Virgil, and closely resembles the ploughs used in Valencia and some parts of France at the present day. In the Vetusta Monumenta (Vol. VI. *see* Bayeux Tapestry, A.D. 1032) drawings may be seen of wheel ploughs worked by two horses abreast. Much information on the condition of the plough in the mediæval period may be obtained from the works of Sir Anthony Fitzherbert (1532), "Chief Justice of the Common Pleas, and a farmer of forty years, standing," of Heresbach (1570),—of Walter Blith, whose "Improver Improved" appeared in 1652—of Hartlib (1652), and of Gervase Markham (1631), from which we learn, that turn-rest ploughs were commonly used in Kent, that the sub-soil plough was then known, and that on many of the light lands in Norfolk and Suffolk it was the practice, by using light ploughs with one horse, to get over two and three acres in the course of the day.

The great improvements in the plough took place in the latter half of the eighteenth century, and are due to Small, Wilkie, Finlaison, and others — who introduced iron mould-boards of a different shape, and generally improved the mechanics of the implement.

Ploughs now are made either with one or with two wheels, and these are known as "wheel-ploughs" or they are made without any wheels at all, in which case they are termed "swing-ploughs." The former are generally used in the southern and the latter in the northern districts. In the use of the one, "more judgment than skill" is required, in the other "more skill than judgment;" with the *wheel-plough*, more depends upon the implement and less upon the man;— with the *swing-plough*, more depends upon the man and less upon the implement. With either, the work is necessarily less perfectly done than with the spade, and the great desideratum of the day is to contrive a machine that shall have the efficiency of the spade and the capability of the plough. Many attempts have been made, but, until recently, without any thing like successful results.

Amongst the most prominent of them is the digging machine

exhibited in Hyde Park by Thompson — where also was shewn a working model of another digging machine by Parsons, which exhibited much ingenuity and combined many desirable points. This has since undergone improvements in various details, and is intended to be rendered locomotive. A machine for effecting the same purpose, patented by Roberts, has been tried and is likely through the assistance of steam to be brought to bear successfully as a cultivator.

Steam traction ploughs are by no means new. Some eighteen years ago one was exhibited at the Highland Society's Meeting at Dumfries, and Lord Willoughby D'Eresby has constantly employed one, arranged by himself, on his Lincolnshire estates.

The Marquis of Tweeddale, whose name is so well and so honourably known in connexion with agricultural improvements, has recently adapted a plough, or rather frame of ploughs, for carrying out his system of *deep* ploughing. In this case two engines are employed, one at either end of the field, the plough-frame travelling by means of traction chains between them, and doing the work, some twelve to fifteen inches deep, in a most efficient manner. There appears to be a question as to whether, all things considered, there is much gained by the application of steam thus limited to the traction merely of the implement. In most cases where steam has successfully supplanted labor, it has demanded that the old processes be laid aside, and new ones, suited to the advanced requirements, be adopted. The plough, itself universally acknowledged to be a defective implement, has no claims to exception to this rule, and certainly the small amount of success attending the steam traction ploughs would be evidence in favour of it.

An attempt has been made by Usher of Edinburgh, to construct a machine that shall by one operation satisfy all the requirements of cultivation. This has been tried in the field with favourable results, and it certainly possesses more of the elements of success than any other that has hitherto been brought out. The old plough is thrown aside and only the share and mould-board made use of; some three to six rows of them are arranged round a large cylinder which is attached to a locomotive engine. When at work in the field the power is applied to this cylinder, which, by its revolution, drives the ploughs (or other instruments as the case may be) into the soil, and thus acts as the propelling agent to the whole machine. The soil is left in a broken condition, as by the fork or spade, and arrangements exist by which the three operations of moving the soil, sowing, and covering in the seed are done at the same time. It travels at the rate of three miles an hour = to nine acres a day, or, allowing for turning, stoppages, &c. say seven acres, which it has done in its various trials, for an expenditure of seventeen and sixpence, or two and sixpence per acre It travels well on common roads, ascending acclivities of one in ten, and turning round in a circle of sixteen feet diameter, and is adapted for any other purpose to which steam power is applied.

Let us see what would be the result of the substitution of the steam plough for our present systems of ploughing. In England, taking Caird's estimate, there are 14,000,000 acres in tillage; these are ploughed certainly once every year. The cost of the operation averages at least ten shillings per acre — thus giving a total of £7,000,000, per annum. This first machine of Usher *does* the work better than by the plough, for two and sixpence per acre, or at seventy-five per cent. less cost. The saving would consequently be about £5,250,000 per annum. The labour of 50,000 men and 100,000 horses required for this one operation would be replaced, and a saving in the consumption of corn effected, to at least 1,500,000 quarters, which would be thus rendered available for the more direct wants of the community.

[I. W.]

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## WEEKLY EVENING MEETING,

Friday, March 4.

THE DUKE OF NORTHUMBERLAND, K.G., F.R.S., President, in the Chair.

EDWARD A. FREEMAN, ESQ., M.A.

*On the Constructive Principles of the Principal Styles of Architecture.*

THE Lecturer stated his object to be to trace out the essential character of the principal styles of architecture as directly derived from their constructive principles, with as little reference as possible either to mere ornamental detail, or to the outlines and ground-plans of buildings. The latter are closely connected with the question of actual style; they modify it and they are modified by it; but they are directly derived from considerations of habit, convenience, or religion, rather than from the real constructive origin and principle of the style itself.

The constructive origin of each primitive and unborrowed style is generally to be looked for in the sort of primitive habitation which each nation seems to have imitated in its first architectural works, that namely with which each had been most familiar in its primitive and uncivilized state. This subject has been worked out in the well-known Essay of Mr. Hope, and more recently treated of by the Lecturer himself in his History of Architecture. The Egyptian architecture reproduced the primitive excavation, the Grecian the primitive hut, the Chinese the primitive tent; each presenting a stone imitation of the earlier and ruder fabric.

The constructive principle of a style depends upon the manner in which it connects distant masses, as when two walls are connected by a roof, or two jambs united into a doorway. This connexion must be effected in one of two ways, either by the *Entablature* or the *Arch*. In the Entablature system the two upright masses are connected by a third laid on the top of them, and kept together simply by cohesion; in the Arch system, the connexion is effected by a series of masses (technically called voussoirs) which, when arranged in a certain manner, are kept together without direct support from below, according to a certain law of the mechanical powers. The entablature can only have one direction, one essentially horizontal; but of the arch there are two principal forms, the round and the pointed, whose æsthetical effect is widely different. Hence we have three principal forms, the *Entablature*, the *Round Arch*, the *Pointed Arch*; each having its own leading idea, those respectively of *horizontal extension*, of simple *rest*, and of *vertical extension*, which are found carried to perfection in the three great styles of architecture, the Grecian, the Romanesque, and the Gothic.

The simple unadorned construction of the entablature may be traced in many primitive monuments, such as the disinterred cromlechs of north-western Europe, the so called Druidical circles of the same region, and some of the rudest among the Pelasgian gateways of Greece and Italy. In a decorative form it produced several important styles of architecture, the native Indian, Persian, and Egyptian styles (all of which must be carefully distinguished from the later works of the Mahometan conquerors in the same countries), and its perfection, the pure and unsurpassable architecture of Greece.

These four agree in their constructive principle; they differ in their constructive origin. The Indian and Egyptian are derived from the imitation of excavations in the rock, the Persian and Grecian from the imitation of erections of timber. Passing by the two inferior and less important styles of India and Persia, the Lecturer proceeded to contrast at length the two great forms of entablature architecture, the Egyptian and the Grecian.

On this head he warmly combated the idea that Grecian architecture was in any way borrowed from Egyptian. He would not at all depreciate the high position belonging to the Egyptian nation, as having attained a great degree of civilization at a very early period, or the great merit of the Egyptian architecture as the first distinct style developed, and one in a high degree stately and solemn, and admirably adapted to the nature of the country and to the genius and the religion of its inhabitants. But he could never admit that a stationary, undeveloping people could ever have had any important influence on a nation whose every product bears the stamp of originality, and which has been the permanent teacher

of the human race alike in arts, and arms, and literature, and politics. Our poetry, our philosophy, our institutions, our architecture, are either lineally (however remotely) descended from those of Greece, or have been subject to most important Grecian influence; no such influence can ever be shown on the part of Egypt. The Lecturer argued that both external and internal evidence was against any derivation of Greek architecture from Egypt.

First, chronology shows us that Greek architecture had begun to exhibit its distinctive features, though by no means in their full perfection, before any intercourse had arisen between Greece and Egypt. That intercourse began in the reign of Psammetichus. Those who assert the derivation of Greek architecture from Egypt never assign it to so late a date, but revert to the fables of Inachus, Danaus, or Cecrops, which the light of modern historical criticism in the hands of Mr. Grote and others has taught us to reject as mere recent inventions. None of these stories derive the least authority from the Homeric poems; it is clear that the only barbarian nation of whom Homer had any clear notion were the Phœnicians; of Egypt he knew just as much as he might have picked up from them. If there be any Egyptian element in Greece, it must have come indirectly through the Phœnicians; but even of this no proof has been offered.

Secondly, the whole character of the two architectures is against the supposition; the Egyptian, as was before said, being derived from excavations, the Grecian from timber structures. The Lecturer pointed out that all the peculiarities of Egyptian architecture were due to its excavation, referring to his History of Architecture for a more detailed view of the subject. He instanced

1st. The general massiveness of the style.

2nd. The general tendency to sloping walls, of which the pyramids are the full development.

3rd. The character of the intercolumniations, as little more than perforations in the wall.

4th. The stilt or dé on the capital.

5th. The presence of a base and absence of diminution in the shaft — sometimes the actual presence of a counter diminution.

6th. The manner in which painting and sculpture are applied.

7th. The absence of a pediment.

In all these points he endeavoured to trace out vestiges of the excavatory origin of the style, and in the opposite characteristics of Grecian architecture, no less clear marks of its timber derivation.

The true Grecian architecture is the Doric, the direct emanation of the Grecian period, the pure representation of the timber construction. In the great Doric temples of Athens, the idea of horizontal extension, the soul of the entablature construction, is per-

fectly realised. The Ionic order is probably of foreign origin, and is decidedly a dereliction from the purity of Grecian architecture. Dr. Layard has found some capitals at Nineveh strongly resembling it; and as the Ionic order arose among the Asiatic Greeks, who were not so pure as their brethren in Hellas, one may reasonably suppose that it was really an innovation derived from a barbaric source.

Turning to the arched construction, there can be little doubt that the arch was independently invented in several widely distant ages and countries. Such at least seems to have been the case in China, in Egypt, and in Italy. And unsuccessful attempts at its formation are found still more extensively, not only in the two latter countries, and in Greece and Asia Minor, but also in the mysterious ruined cities of Central America, and in some of the primitive remains in Scotland described by Dr. Daniel Wilson in his "Archæology and Prehistoric Annals." The arched form must be accurately distinguished from the arched construction, as the *apparent arch* often occurs, which has the form, round or pointed, but which is merely composed of overlapping stones cut into that shape, not of voussoirs mutually supporting one another. Numerous varieties, both of the apparent arch, and of attempts at constructing the real one, will be found in Dodwell's Views, and in the more recent works of Sir Charles Fellows. And it is worth noticing that the pointed form seems to have been attempted quite as early, if not earlier, than the round. Indeed, if the first attempt, as seems not unlikely, took the form of overlapping stones inclining to a point, it would clearly be more easy to cut them away into a pointed than into a round shape. The complete form of the pointed arch is found in a gateway at Thoricos, and a very near approach to its construction in one at Tiryns. It would seem however that the attempt never quite succeeded, and that the greater apparent strength of the round arch drove the designs back upon that form, which was at last brought to perfection both in Italy and Egypt. Whether such was the case in Greece appears extremely doubtful.

At all events neither in Greece nor in Egypt did the invention ever give birth to a truly arched architecture. The arch was freely used in Egypt when constructive necessities required, but it never entered into the system of decorative architecture, which was always constructed on the principle of the entablature. The honour of producing a system of architecture of which the arch should be the leading feature was reserved for Italy. Those Roman buildings in which decoration was not aimed at, present, in their square piers and round arches, all the elements of a good and consistent style of architecture. But, as a general rule, the Roman architects in their ornamental structures endeavoured to effect an union of their own system of piers and arches with the Greek system of columns and entablatures, producing an inharmonious

and inconsistent result. Numerous instances of the ways in which this union was attempted have been commented on in Mr. Hope's work, while, on the other hand, Mr. Petit has well traced out the way in which, in less enriched structures, the Grecian system of decoration was gradually cast away, becoming altogether secondary in the amphitheatres, and vanishing entirely from the aqueducts. The latter, such as the Pont du Gard in Languedoc, exhibit the system of piers and round arches in its perfect purity. On the other hand, in the palace of Diocletian at Spalato, and in the early Basilicas, the architects boldly allowed the arch to spring directly from the capital of the column, without the intervention of the entablature in any shape. Buildings like these, so far from being examples of a corrupt style, are, in the eye of a philosophical inquirer, the first steps towards restoring Roman architecture to a real purity and consistency which in its palmy days it had never possessed. The true round arched system was now worked out, and the arch provided with an appropriate support of two kinds, the square and the columnar pier.

The various forms of Romanesque architecture, the Byzantine, the Lombard of Italy, the Provençal, the German of the Rhine, the Norman of England and Northern France, all adhere to this same construction, and gradually work out for it an appropriate system of decoration. The Byzantine architecture, as far as the present view is concerned, must be considered as merely one among several varieties of Romanesque; in other respects, the peculiar outlines of its ecclesiastical buildings, and its especial use of the cupola, the noblest offspring of the round arch, might fairly cause it to be looked upon as a distinct class. The German and Norman architecture has gone very far to realize the ideal of the round-arched style, the architecture of mere rest and solidity, without any predominant extension, horizontal and vertical. The Lecturer argued warmly in favour of the claim of this style to be considered a pure and perfect one, worthy of being classed alongside of Grecian and Gothic. Romanesque architecture, he contended, had been depreciated, because both classical and Gothic exclusiveness had looked on it with an unfavourable eye; but it was quite possible that a style might be neither Grecian or Gothic, and yet be worthy of being put on an equality with them. If, like them, Romanesque exhibited the full carrying out of the leading æsthetical idea suggested by its own constructive principle, such equality it might fairly claim. At the same time an absolute equality he would not assert; the Gothic ideal was the highest, while the Grecian buildings had attained a higher perfection in their own kind; for the Romanesque ideal itself he would be content with claiming the rank of *ultima inter pares*, while he was inclined to believe that no Romanesque building had approached so

near to the perfect realization of that ideal, has had been done in the two other styles by the Parthenon and by St. Ouens.

While the Romanesque styles were growing up among Christian nations, a very important form of arched architecture was developed among the Mahometan nations. The Saracenic style, in its various forms, may be considered as essentially an offshoot from that of Byzantium, though much modified by the introduction of several original elements. Among these the most important was no other than the systematic use of the pointed arch. This shape is prevalent in most of the forms which this species of architecture assumes in the east, but, what is important to observe, such is not the case in that splendid variety which was developed among the Mahometans of Spain. But though the Saracens not only possessed the pointed arch, but systematically employed it on a grand scale, they never developed for it an appropriate system of decoration. The other most characteristic feature is the employment of the *stilt* as a distinct member of the architecture. Architecture is always purest when what Professor Willis calls the decorative construction coincides with the mechanical construction. According to this law, the point at which the arch springs from the pier, technically called the impost, should be marked by a capital or moulding. It is however often convenient in some particular positions to place the decorative impost lower down than the constructive impost, so as to treat as a portion of the arch what is in reality a portion of the pier. This constitutes what is called a *stilted* arch. In the Saracenic style, this *stilt* is often made into a distinct member intervening between the arch and the capital of the column. Now as this style first arose in Egypt in the Mosque erected by Amru, one is strongly tempted to recognize in this singular feature a reproduction of the exactly analogous peculiarity of the elder Egyptian architecture, the dé interposed between the capital and the entablature.

The distinctive feature of the Gothic architecture is therefore neither the mere form of the pointed arch, nor even its systematic use as the principal constructive member. What really distinguishes that glorious style is the working out for it of an appropriate and harmonious system of decoration, and the realizing of the great æsthetical idea which it suggests. The mere form, we have seen, is probably more ancient than the round, and may have been all along occasionally employed as caprice or convenience dictated. And that its systematic use as the principal constructive feature was introduced into Western Christendom from the east, we can hardly doubt, when we consider that its appearance in the twelfth century is exactly simultaneous with the increased intercourse between the two regions consequent upon the Crusades. We may thus see the

futility of the various theories propounded by Milner and others, who reduced the question as to the origin of Gothic architecture into a mere question as to the origin of the pointed arch, and sought for the latter in the intersection of round arches and similar sources.

From the Orientals then the western architects learned systematically to employ the pointed arch in the main arcades of their churches and other great buildings,* of which the Abbey of Malmesbury is not improbably the earliest example in England. But much more remained to be done before Gothic architecture was fully developed; in other words, before the architectural expression of the idea of vertical extension was thoroughly worked out. Those who laid its foundations did but place the pointed arch of the Saracen upon the massive pier of the Norman, and channel its surface with the same ornaments which had adorned its semicircular predecessor. Slowly and gradually was a harmonious system worked out, the progress of this transition forming one of the most interesting pages in the history of the art. The pointed form was extended from the great constructive arches to the smaller arches of doorways, windows, and merely decorative arcades, and the Gothic or vertical principle was carried out in

1st. The use of mouldings affecting the section.
2nd. The clustered, or its substitute the octagonal, pier.
3rd. The round or octagonal instead of the square abacus.
4th. The confirmed use of vaulting.†

Into the subdivisions of the Gothic style, which he had fully treated of in other works, the Lecturer refrained from entering. He would simply mention its two great forms, the Early, in which the principle of subordinating the parts to the whole, so characteristic of Gothic architecture, is applied only to the subordination of the secondary to the primary parts, and the Continuous, which while effecting this more completely, extends the same principle to the further subordination of the primary parts to the whole. The former includes the Lancet and Geometrical Decorated; the latter the Flowing Decorated, the Perpendicular of England, and the contemporary Flamboyant of the continent.

[E. A. F.]

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Mr. Faraday read the following letter which he had received from Mr. Stevenson, relative to the coincidence of a secular period in the

* See History of Architecture, pp. 311-3.
† See them examined more at length, History of Architecture, pp. 303-8.

recurrence of the aurora borealis with that observed in relation to the sun's spots and the daily magnetic variation (Vide p. 237).

*Dunse (N. Britain)*, 1 *March*, 1853.

Dear Sir,

In the report in the Athenæum of your lecture at the Royal Institution on the 21st January, I observe that you refer to the highly interesting observations of Schwabe, Sabine, Wolf, Gautier, &c., from which it would appear that a connexion exists between the solar spots and the variation of the terrestrial magnetic forces. Since a connexion has been demonstrated to exist between the latter and auroral phenomena, I was induced to look over my notes relating to the auroræ observed at this place, with a view to ascertain whether these also exhibited maxima and minima; and if so, whether the periods of such agreed with those of the solar spots and of the magnetic variations. The subjoined table shews the distribution of the auroræ seen here in the years 1838 to 1847 inclusive.

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Sum. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1838 | 5 | 3 | 4 | 3 | — | — | — | 2 | 4 | 1 | 2 | 3 | 27 |
| 1839 | 9 | 1 | 2 | 4 | 1 | — | — | — | 11 | 7 | 2 | 1 | 38 |
| 1840 | 5 | 5 | 2 | 4 | — | — | — | 3 | 7 | 6 | 6 | 5 | 43 |
| 1841 | 6 | 3 | 4 | 4 | 2 | — | — | 3 | 3 | 3 | 7 | 7 | 42 |
| 1842 | 2 | 2 | — | — | — | — | 1 | — | 3 | — | 1 | — | 9 |
| 1843 | 2 | 1 | 1 | 1 | — | — | — | 2 | — | 3 | — | — | 10 |
| 1844 | 1 | — | 2 | — | — | — | — | — | 1 | 3 | 4 | 2 | 13 |
| 1845 | 1 | 2 | — | 1 | — | — | — | 1 | 2 | 1 | 1 | 1 | 10 |
| 1846 | — | 1 | — | — | — | — | 1 | 2 | 7 | 4 | 1 | — | 16 |
| 1847 | 2 | 2 | 3 | 1 | — | — | — | 1 | 5 | 6 | 6 | 4 | 30 |
| | 33 | 20 | 18 | 18 | 3 | — | 2 | 14 | 43 | 34 | 30 | 23 | 238 |

These figures speak for themselves. I may remark that the returns for 1842 are incomplete, as I was absent from home during March and April of that year. In 1848 I was also absent for some months; but from the number of auroræ which I have noted during that year, I am satisfied that a maximum then occurred both as regards the number and the intensity of auroral displays. This present winter has been very barren in auroral phenomena. Of crimson auroræ, I find I have noted two in 1837, one in 1839, one in 1846, three in 1847, and no less than six in 1848.

A discussion of the auroræ seen in N. America and the North of Europe during a series of years would be interesting in reference to the points in question.

I am, my dear Sir,

Your's faithfully, &c.,

Wm. Stevenson.

## GENERAL MONTHLY MEETING,

Monday, March 7.

SIR CHARLES FELLOWS, Vice President, in the Chair.

De Burgh Birch, M.D.
George T. Brooking, Esq.
William Ernst Browning, Esq.
James Bruce, Esq.
Alexander Duncan, Esq.
Peter Halkett, Esq., R.N.
Charles Seale Hayne, Esq.
Effingham Calvert Lawrence, Esq.
John Line, Esq.
Alexander Mitchell, Esq.
The Count de Montizon.
Miss Ellen Matilda Pickersgill.
Mrs. Harriet Pole.
George Ridley, Esq.
Charles Turner Simpson, Esq., M.A. Fell. Trin. Coll. Camb.
Basil Woodd Smith, Esq.
Charles William Stokes, Esq.
John Newman Tweedy, Esq.
James Vallance, Esq.
William Foster White, Esq.
Alexander Williamson.

were duly *elected* Members of the Royal Institution.

W. Bell Brooking, Esq.
John Henderson, Esq.
John Forster, Esq.
James Vallance, Esq.

were *admitted* Members of the Royal Institution.

The Secretary reported that the following Arrangements had been made for the Lectures after Easter, 1853:

Six Lectures on Static Electricity — by MICHAEL FARADAY, D.C.L., F.R.S., Fullerian Professor of Chemistry, R. I.; Foreign Associate of Academy of Sciences, Paris.

Ten Lectures on Technological Chemistry — by E. FRANKLAND, Ph.D., F.C.S., Professor of Chemistry at Owen's College, Manchester.

Four Lectures on Air and Water — by JOHN TYNDALL, Ph. D., F.R.S.

Six Lectures on the Electric Telegraph — by WILLIAM CARPMAEL, Esq., C.E.

The following PRESENTS were announced and the thanks of the Members returned for the same:—

FROM
*Astronomical Society, Royal* — Monthly Notices. Vol. XIII. No. 2. 8vo. 1853.

*Bayerische Akademie der Wissenschaften* — Abhandlungen der Mathemat.-Physikalischen Classe. Sechste Band, 2te und 3te Abtheilungen. 4to. München, 1851-2.

Bulletin, 1851; und 1852, No. 1—24. 4to. München.

Dr. A. Vogel, über den Chemismus der Vegetation. 4to. München, 1852.

*Bell, Jacob, Esq. M.R.I. (the Editor)* —The Pharmaceutical Journal for March, 1853. 8vo.

*British Architects, Royal Institute of* — Proceedings, Feb. 1853. 4to.

*Civil Engineers, Institute of* — Proceedings, Feb. 1853. 8vo.

*Cocks and Co., Messrs.*— Cock's Musical Miscellany, March, 1853. 4to.

*Council of Education, Calcutta* —Reports on Public Instruction in the Lower Provinces of the Bengal Presidency for 1843—1848. 5 vols. 8vo. 1844-48.

*Editors* — The Practical Mechanic's Journal for March, 1853. 4to.

The Athenæum for Feb. 1853. 4to.

The Medical Circular for March, 1853. 4to.

*Geological Society* — Quarterly Journal, No. 33. 8vo. 1853.

*Knight, Messrs. (the Publishers)* — The Farmer's Manual of Agricultural Chemistry, by A. Normandy, 12mo. 1853.

*Lovell, E. B., Esq., M.R.I. (the Editor)* —The Monthly Digest, Feb. 1853. 8vo.

*Morris, J. Esq.* — De Luc, Physica; De Elementis, (MS.)

*Novello, Messrs.*— The Musical Times for March, 1853. 4to.

*Prince, C. Leeson, Esq., (the Author)* — Results of a Meteorological Journal kept at Uckfield, Sussex, in 1852.

*Richardson, H. T. Esq.*—The Cruise of the Challenger Life-Boat, and Voyage from Liverpool to London in 1852. 12mo. 1853.

*Royal Society* — Proceedings, Vol. VI. No. 91—94. 8vo. 1853.

Transactions for 1852, Part 2. 4to. 1852.

Address of Earl Rosse, the President, Nov. 30. 1852. 8vo. 1853.

*Smith, Mr. J. Russell (the Publisher)* — Bibliotheca Americana — A Catalogue of a valuable Collection of Books and Pamphlets relating to North and South America and the West Indies. 8vo. 1853.

*Society of Arts* — Journal, No. 12—15. 8vo. 1853.

*Statistical Society* — Journal, Vol. XVI. Part 1. 8vo. 1853.

*Taylor, Rev. W., F.R.S., M.R.I.*— Die Zeitgeist, von A. von Schaden. 16mo. Gera, 1828.

*Vereins zur Beförderung des Gewerbfleisses in Preussen* — Verhandlungen, Nov. und Dec. 1852. 4to. Berlin, 1852.

## WEEKLY EVENING MEETING,

Friday, March 11.

The Duke of Northumberland, K.G., F.R.S., President,
in the Chair.

John Phillips, F.R.S., G.S., &c.

*Geological Sketches round Ingleborough.*

The Lecturer prefaced his observations on this the most conspicuous of the Yorkshire Mountains, by a brief allusion to circumstances which, at an early period of life, had fixed his earnest attention on the scenery and natural history of the country which surrounds it.

Viewed in any direction, Ingleborough appears a grand and solitary mass, chiefly composed of shales and sandstones, superposed on a broad floor of limestone which rests on a basis of upturned Lower Palæozoic Rocks. The great limestone floor and the lower rocks are broken off and thrown down to the south and west of the mountain, by the enormous, often double, dislocation called the 'Craven Fault,' and the ground falls in these directions nearly 2000 feet below the summit. Hence the conspicuous character of the mountain, which rises to the height of 2380 feet above the sea.

The streams which gather on the slopes of Ingleborough and Penyghent run in small channels downward over the shales and sandstones, but, on reaching the limestone, they are swallowed up in deep gulphs of that rock, and after passing through caves, many of which are remarkable for beauty, issue to the surface in picturesque channels, and sometimes make pleasing cascades, such as Thornton Force. The most famous of these caverns, which was discovered by the present proprietors of Ingleborough, and traced by them for a length of 702 yards, has, no doubt, been formed by the long continued erosion of a stream which, after gathering on the slopes of Ingleborough, plunges into a deep chasm of the limestone called 'Gaping Gill'; its erosive power being augmented by the sand and pebbles which it hurls down. The interior of this cave is wonderfully varied in form, and enriched by every variety of sparry accumulation — slender pipes, spiral columns, swelling bosses, broad expansions, and, most beautiful of all, white sheets of carbonate of lime which spread like leaves on small basins of the clearest water. From researches

in the cave it appears that, from a certain point of the fissured roof, drops have been falling on a single line for above 120 years.

Turning from the scenery, the author entered on a general history of the mountain. 1. He shewed that the earliest of the strata were, as described by Professor Sedgwick, of the Lower Palæozoic ages, and contained marine exuviæ, but no fishes. 2. These were upheaved so as to form many arched elevations — parts of a great system of movements which affected also the lake district to the west. 3. These great inequalities of surface were worn down by long continued oceanic agitations, so as to present a nearly uniform plane; an effect perfectly wonderful, whatever amount of marine disturbance we suppose to have been exerted, and whatever length of time we allow for its operation. 4. The whole area then sank without violence, and continued to sink for a long period — first receiving a thick deposit of mountain limestone (marble), then a mixed deposit of shales, limestones, and sandstones, then a mass of millstone grit, and finally a great accumulation of coal measures. The total depression beneath the sea from the preceding condition (3) was estimated at one mile. 5. It was then shewn that a violent convulsive movement, accompanied by enormous fractures, had displaced the sea-bed, and produced a great elevation of the country, so that, as compared with the lower portions of the strata on the south, west, and north, there was in some places a difference of level of the same strata, amounting to 4000 feet.

6. As a consequence of this great convulsion, and the watery agencies consequent upon it, the coal-measures and great part of the other strata which covered the limestone floor of Ingleborough were swept away,— an enormous waste,— leaving the mountains of Whernside, Ingleborough, and Penyghent, standing above the sea, but far lower than the height which the land had reached during or immediately after the disturbance. 7. The extent of *land* connected with these hills at the termination of this period of convulsion was then shewn, and it was stated that the higher parts of this land had perhaps never again been covered by oceanic water — so that, in the immense period while the New Red, Lias, Oolite, and Chalk were deposited, these hills, not indeed in their present form, may have stood perpetually above the ancient ocean. Enaliosaurians may have been swimming within sight of Ingleborough,— Megalosaurians and Pterodactyls may have wandered over its slopes,— many systems of life corresponding to many successive ages arose and passed away, on the land and in the sea, but of all these there is no record *here*. At length, in the latest tertiary æras, the Glacial crisis arrived, and left positive traces of its effects.

8. The depression of land was then described which occasioned the 'Glacial Sea' in the northern zones, and certain phenomena were explained which proved the singular fact, that abundance of

'erratic blocks' of Silurian Strata, had *been drifted to higher levels* on the limestone which covers those Silurians. The author does not suppose that this glacial ocean reached more than 1500 feet above the present level, and consequently believes that a large part of the north west of Yorkshire was not covered by its waters. The Botany of Ingleborough offers several peculiarities ; — and joining its history to that of the higher mountains in the north, which have traces of a 'Scandinavian Flora,' the author expressed his concurrence in the views of Professor E. Forbes, as to the former existence of land connecting Scotland and Scandinavia, and his belief that on the formation of the glacial sea, the summits of the highest Yorkshire mountains remained above the water, and were the retreat of peculiar plants now found in this part of Yorkshire, in the Grampians, and in Scandinavia.

9. The author finally described a British Walled Camp, and the foundations of nineteen circular huts which had been discovered on the summit of Ingleborough, and concluded by remarking on the analogy and almost necessary connexion between certain branches of archæology and modern views of the geological history of the globe.

[J. P.]

[FOR THE USE OF MEMBERS.]

# Royal Institution of Great Britain.

1853.

## WEEKLY EVENING MEETING,

Friday, March 18.

WILLIAM POLE, ESQ., M.A., F.R.S., Treasurer, and Vice-President, in the Chair.

SIR C. LYELL, F.R.S., V.P.G.S., &c.

*On the discovery of some fossil reptilian remains, and a land-shell in the interior of an erect fossil-tree in the Coal measures of Nova Scotia, with remarks on the origin of Coal-fields, and the time required for their formation.*

THE entire thickness of the carboniferous strata, exhibited in one uninterrupted section on the shores of the Bay of Fundy, in Nova Scotia, at a place called the South Joggins and its neighbourhood, was ascertained by Mr. Logan, to be 14,570 feet. The middle part of this vast series of strata having a thickness of 1400 feet, abounds in fossil forests of erect trees together with root-beds, and thin seams of coal. These coal-bearing strata were examined in detail by Mr. J. W. Dawson of Pictou, and Sir C. Lyell in September last (1852), and among other results of their investigations they obtained satisfactory proof that several Sigillariæ standing in an upright position, or at right angles to the planes of stratification, were provided with stigmariæ as roots. Such a relation between Sigillaria and Stigmaria had, it is true, been already established by Mr. Binney of Manchester, and had been suspected some years before on botanical grounds by M. Adolphe Brongniart; but as the fact was still doubted by some geologists both in Europe and America, it was thought desirable to dig out of the cliffs, and expose to view, several large trunks with their roots attached. These were observed to bifurcate several times, and to send out rootlets in all directions into the clays or ancient soils in which they had grown. Such soils or underclays with Stigmaria afford more conclusive evidence of ancient terrestrial surfaces than even erect trees, as the latter might be conceived to have been drifted and fixed like snags in a river's bed. In the strata 1400 feet thick above mentioned root-bearing soils were observed at sixty-eight different levels; and like the seams of coal which usually cover them, they are at present the most destructible masses in the whole cliff, the sandstones and laminated shales being harder and more capable of resisting the action of the

waves and the weather. Originally the reverse was doubtless true, for in the existing delta of the Mississippi the clays in which innumerable roots of swamp trees, such as the deciduous cypress, ramify in all directions, are seen to withstand far more effectually the excavating power of the river or of the sea at the base of the delta, than do beds of loose sand or layers of mud not supporting trees.

This fact may explain why seams of coal have so often escaped denudation, and have remained continuous over wide areas, since the roots, now turned to coal, which once traversed them would enable them to resist a current of water, whilst other members of the coal formation, when in their original and unconsolidated state consisting of sand and mud, would be readily removed.

The upright trees usually inclose in their interior pillars of sandstone, or shale, or both these substances alternating, and these do not correspond in the thickness of their layers, or in their organic remains, with the external strata, or those enveloping the trunks. It is clear therefore that the trees were reduced while yet standing to hollow cylinders of mere bark, (now changed to coal,) into which the leaves of ferns and other plants with fragments of stems and roots were drifted together with mud and sand during river inundations. The stony contents of one of these trees, nine feet high and twenty-two inches in diameter, on being examined by Messrs. Dawson and Lyell yielded, besides numerous fossil plants, some bones and teeth which they believed were referable to a reptile; but not being competent to decide that osteological question they submitted the specimens to Dr. Jeffries Wyman of Harvard University in the United States. That eminent anatomist declared them to be allied in structure to certain perennibranchiate batrachians of the genera Menobranchus and Menopoma, species of which now inhabit the lakes and rivers of North America. This determination was soon afterwards confirmed by Professor Owen of London, who pointed out the resemblance of some of the associated flat and sculptured bones, with the cranial plates, seen in the skull of the Archegosaurus and Labyrinthodon.* In the same dark-coloured rock, Dr. Wyman detected a series of nine vertebræ, which from their form and transverse processes he regards as dorsal, and believes them to have belonged to an adult individual of a much smaller species, about six inches long, whereas the jaws and bones before mentioned are those of a creature probably two and a half feet in length. The microscopic structure of these small vertebræ was found by Professor Quekett to exhibit the same marked reptilian characters as that of the larger bones.

The fossil remains in question were scattered about the interior of the trunk near its base among fragments of wood, now converted into charcoal, which may have fallen in while the tree was rotting

* Professors Wyman and Owen have named the reptile Dendrerpeton Acadianum, Acadia being the ancient Indian name for Nova Scotia.

away, having been afterwards cemented together by mud and sand stained black by carbonaceous matter. Whether the reptile crept into the hollow tree while its top was still open to the air, or whether it was washed in with mud during a flood, or in whatever other manner it entered, must be matter of conjecture. Foot-prints of two reptiles of different sizes have been observed by Dr. Harding and Dr. Gesner on ripple-marked flags of the lower coal measures in Nova Scotia, evidently made by quadrupeds walking on the beach, or out of the water, just as the recent Menopoma is sometimes observed to do. Other reptilian foot-prints of much larger size had been previously noticed (as early as 1844) in the coal of Pennsylvania by Dr. King; and in Europe three or four instances of skeletons of the same class of animals have been obtained, but the present is the first example of any of their bones having been met with in America in rocks of higher antiquity than the Trias. It is hoped however that other instances will soon come to light, when the contents of upright trees, so abundant in Nova Scotia, have been systematically explored; for in such situations the probability of discovering ancient air-breathing creatures seems greater than in ordinary subaqueous deposits. Nevertheless we must not indulge too sanguine expectations on this head, when we recollect that no fossil vertebrata of a higher grade than fishes, nor any land-shells, have as yet been met with in the Oolitic coal-field of the James River, near Richmond, Virginia, a coal-field which has been worked extensively for three-quarters of a century. The coal alluded to is bituminous, and as a fuel resembles the best of the ancient coal of Nova Scotia and Great Britain. The associated strata of sand-stone and shale contain prostrate zamites and ferns, and erect calamites and equiseta, which last evidently remain in the position where they grew in mud and sand. Whether the age of these beds be Oolitic as Messrs. W. B. Rogers and Lyell have concluded, or Upper Triassic as some other geologists suspect, they still belong clearly to an epoch when saurians and other reptiles flourished abundantly in Europe; and they therefore prove that the preservation of ancient terrestrial surfaces even in secondary rocks does not imply, as we might have anticipated, conditions the most favourable to our finding therein creatures of a higher organization than fishes.

In breaking up the rock in which the reptilian bones were entombed, a small fossil body resembling a land shell of the genus Pupa, was detected. As such it was recognized by Dr. Gould of Boston, and afterwards by M. Deshayes of Paris, both of whom carefully examined its form and striation. When parts of the surface were subsequently magnified 250 diameters, by Professor Quekett of the College of Surgeons, they were seen to exhibit ridges and grooves undistinguishable from those belonging to the striation of living species of land-shells. The internal tissue also of the shell displayed, under the microscope, the same prismatic and tubular arrangements which characterize the shells of living mollusca,

Sections also of the same showed what may be part of the columella and spiral whorls, somewhat broken and distorted by pressure and crystallized. The genus cannot be made out, as the mouth is wanting. If referable to a pupa or any allied genus it is the first example of a pulmoniferous mollusk hitherto detected in a primary or palæozoic rock.

Sir Charles next proceeded to explain his views as to the origin of coal-fields in general, observing that the force of the evidence in favour of their identity in character with the deposits of modern deltas, has increased, in proportion as they have been more closely studied. They usually display a vast thickness of stratified mud and fine sand without pebbles, and in them are seen countless stems, leaves, and roots of terrestrial plants, free for the most part from all intermixture of marine remains, circumstances which imply the persistency in the same region of a vast body of fresh water. This water was also charged like that of a great river with an inexhaustible supply of sediment, which had usually been transported over alluvial plains to a considerable distance from the higher grounds, so that all coarser particles and gravel were left behind. On the whole the phenomena imply the drainage and denudation of a continent or large island, having within it one or more ranges of mountains. The partial intercalation of brackish water-beds at certain points is equally consistent with the theory of a delta, the lower parts of which are always exposed to be overflowed by the sea even where no oscillations of level are experienced.

The purity of the coal itself, or the absence in it of earthy particles and sand throughout areas of very great extent, is a fact which has naturally appeared very difficult to explain if we attribute each coal-seam to a vegetation growing in swamps, and not to the drifting of plants. It may be asked how during river inundations capable of sweeping away the leaves of ferns, and the stems and roots of Sigillariæ and other trees, could the waters fail to transport some fine mud into the swamps? One generation after another of tall trees grew with their roots in mud, and after they had fallen prostrate and had been turned into coal were covered with layers of mud (now turned to shale), and yet the coal itself has remained unsoiled throughout these various changes. The Lecturer thinks this enigma may be solved, by attending to what is now taking place in deltas. The dense growth of reeds and herbage which encompasses the margins of forest-covered swamps in the valley and delta of the Mississippi, is such that the fluviatile waters in passing through them, are filtered and made to clear themselves entirely before they reach the areas in which vegetable matter may accumulate for centuries, forming coal if the climate be favourable. There is no possibility of the least intermixture of earthy matter in such cases. Thus in the large submerged tract call the "Sunk Country," near New Madrid, forming part of the Western side of the valley of the Mississippi, erect trees have been standing ever since the year 1811-12, killed by the great

earthquake of that date; Lacustrine and swamp plants have been growing there in the shallows, and several rivers have annually inundated the whole space, and yet have been unable to carry in any sediment within the outer boundaries of the morass.

In the ancient coal of the South Joggins in Nova Scotia, many of the underclays show a network of stigmaria roots, of which some penetrate into or quite through older roots which belonged to the trees of a preceding generation. Where trunks are seen in an erect position buried in sandstone and shale, rooted Sigillariæ or Calamites are often observed at different heights in the enveloping strata, attesting the growth of plants at several successive levels, while the process of envelopment was going on. In other cases there are proofs of the submergence of a forest under marine or brackish water, the base of the trunks of the submerged trees being covered with serpulæ or a species of spirorbis. Not unfrequently seams of coal are succeeded by beds of impure bituminous limestone, composed chiefly of compressed modiolæ with scales and teeth of fish, these being evidently deposits of brackish or salt water origin.

The Lecturer exhibited a joint of the stem of a fresh water reed (*Arundinaria macrosperma*) covered with barnacles, which he gathered at the extremity of the delta of the Mississippi or the Balize. He saw a cane-brake (as it is called in the country) of these tall reeds killed by salt water, and extending over several acres, the sea having advanced over a space where the discharge of fresh water had slackened for a season in one of the river's mouths. If such reeds when dead could still remain standing in the mud with barnacles attached to them, (these crustacea having been in their turn destroyed by a return of the river to the same spot,) still more easily may we conceive large and firmly rooted Sigillariæ to have continued erect for many years in the Carboniferous Period, when the sea happened to gain on any tract of submerged land.

Submergence under salt water may have been caused either by a local diminution in the discharge of a river in one of its many mouths, or more probably by subsidence, as in the case of the erect columns of the Temple of Serapis, near Naples, to which serpulæ and other marine bodies are still found adhering.

Sir Charles next entered into some speculations respecting the probable volume of solid matter contained in the carboniferous formation of Nova Scotia. The data he said for such an estimate are as yet imperfect, but some advantage would be gained could we but make some slight approximation to the truth. The strata at the South Joggins are nearly three miles thick, and they are known to be also of enormous thickness in the district of the Albion Mines near Pictou, more than one hundred miles to the eastward. There appears therefore little danger of erring on the side of excess, if we take half that amount or 7500 feet as the average thickness of the whole of the coal measures. The area of the coal-field, including part of New Brunswick to the West, and Prince Edward's

Island and the Magdalen Isles to the North, as well as the Cape Breton beds together with the connecting strata which must have been denuded or must still be concealed beneath the waters of the Gulf of St. Lawrence, may comprise about 36,000 square miles, which with the thickness of 7500 feet before assumed will give 7,527,168,000,000,000 cubic feet, (or 51,136.4 cubic miles) of solid matter as the volume of the rocks. Such an array of figures conveys no distinct idea to the mind; but is interesting when we reflect that the Mississippi would take more than two million of years (2,033,000 years) to convey to the Gulf of Mexico, an equal quantity of solid matter in the shape of sediment, assuming the average discharge of water, in the great river, to be as calculated by Mr. Forshey, 450,000 cubic feet per second, throughout the year, and the total quantity of mud to be as estimated by Mr. Riddell, 3,702,758,400 cubic feet in the year.*

We may, however, if we desire to reduce to a minimum the possible time required for such an operation, (assuming it be one of fluviatile denudation and deposition,) select as our agent, a river flowing from a tropical country, such as the Ganges, in the basin of which the fall of rain is much heavier, and where nearly all comes down in a third part of the year, so that the river is more turbid than if it flowed in temperate latitudes. In reference to the Ganges, also, it may be well to mention, that its delta presents in one respect a striking parallel to the Nova Scotia Coal-field, since at Calcutta at the depth of eight or ten feet from the surface buried trees and roots have been found in digging tanks, indicating an ancient soil now underground; and in boring on the same site for an Artesian well to the depth of 481 feet, other signs of ancient forest-covered lands and peaty soils have been observed at several depths, even as far down as 300 feet and upwards below the level of the sea. As the strata pierced through contained fresh-water remains of recent species of plants and animals, they imply a subsidence, which has been going on contemporaneously with the accumulation of fluviatile mud.

Captain Strachey of the Bengal Engineers has estimated that the Ganges must discharge $4\frac{1}{2}$ times as much water into the Bay of Bengal, as the same river carries past Ghazipore, a place 500 miles above its mouth, where experiments were made on the volume of water and proportion of mud by the Rev. Mr. Everest. It is not till after it has passed Ghazipore, that the great river is joined by most of its larger tributaries. Taking the quantity of sediment at one-third less than that assigned by Mr. Everest for the Ghazipore average, the volume of solid matter conveyed to the Bay of Bengal would still amount to 20,000 millions of cubic feet annually. The Ganges therefore might accomplish in 375,000 years the task which it would take the Mississippi, according

* See Principles of Geology, 8th Ed. p. 219.

to the data before laid down, upwards of two million years to achieve.

One inducement to call attention to such calculations is the hope of interesting engineers in making accurate measurement of the quantity of water and mud discharged by such rivers as the Ganges, Brahmapootra, Indus, and Mississippi, and to lead geologists to ascertain the number of cubic feet of solid matter, which ancient fluviatile formations, such as the coal-measures, with their associated marine strata, may contain. Sir Charles anticipates that the chronological results, derived from such sources, will be in harmony with the conclusions to which botanical and zoological considerations alone might lead us, and that the lapse of years will be found to be so vast as to have an important bearing on our reasonings in every department of geological science.

A question may be raised, how far the co-operation of the sea in the deposition of the Carboniferous Series might accelerate the process above considered. The Lecturer conceives that the intervention of the sea would not afford such favourable conditions for the speedy accumulation of a large body of sediment within a limited area, as would be obtained by the hypothesis before stated, namely, that of a great river entering a bay in which the waves, currents, and tides of the ocean should exert only a moderate degree of denuding and dispersing power.

An eminent writer, when criticizing, in 1830, Sir Charles Lyell's work on the adequacy of existing causes, was at pains to assure his readers, that while he questioned the soundness of the doctrine he by no means grudged any one the appropriation of as much as he pleased of that "least valuable of all things, past time." But Sir Charles believes, notwithstanding the admission so often made in the abstract of the indefinite extent of past time, that there is practically speaking a rooted and perhaps unconscious reluctance on the part of most geologists to follow out to their legitimate consequences the proofs daily increasing in number of this immensity of time. It would therefore be of no small moment could we obtain even an approach to some positive measure of the number of centuries which any great operation of nature such as the accumulation of a delta or fluviatile deposit of great magnitude may require, inasmuch as our conceptions of the energy of aqueous or igneous causes or of the powers of vitality in any given geological period must depend on the quantity of time assigned for their development.

Thus, for example, geologists will not deny that a vertical subsidence of three miles took place gradually at the South Joggins, during the carboniferous epoch, the lowest beds of the Coal of Nova Scotia like the middle and uppermost consisting of shallow-water beds. If then this depression was brought about in the course of 375,000 years it did not exceed the rate of four feet in a century, resembling that now experienced in certain countries where whether the movement be upward or downward it is quite insensible to

the inhabitants, and only known by scientific inquiry. If, on the other hand, it was brought about in two millions of years according to the other standard before alluded to, the rate would be only six inches in a century. But the same movement taking place in an upward direction would be sufficient to uplift a portion of the earth's crust to the height of Mont Blanc or to a vertical elevation of three miles above the level of the sea. In like manner, if a large shoal be rising, or attempting to rise, in mid-ocean at the rate of six inches or even four feet in a hundred years, the waves may grind down to mud and sand and readily sweep away the rocks so upraised as fast as they come within the denuding action of the waves. A mass having a vertical thickness of three miles might thus be stripped off in the course of ages, and inferior rocks laid bare. So in regard to volcanic agency a certain quantity of lava is poured out annually upon the surface, or is injected into the earth's crust below the surface, and great metamorphic changes resulting from subterranean heat accompany the injection. Whether each of these effects be multiplied by 50,000, or by half a million or by two million of years, may entirely decide the question whether we shall or shall not be compelled to abandon the doctrine of paroxysmal violence in ancient as contrasted with modern times. Were we hastily to take for granted the paroxysmal intensity of the forces above alluded to, organic and inorganic, while the ordinary course of nature may of itself afford the requisite amount of aqueous, igneous, and vital force, (if multiplied by a sufficient number of centuries,) we might find ourselves embarrassed by the possession of twice as much mechanical force and vital energy as we require for the purposes of geological interpretation.

[C. L.]

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## GENERAL MONTHLY MEETING,

Monday, April 4.

WILLIAM POLE, ESQ. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

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| William Bigg, Esq. | Sir Jas. Matheson, Bt. M.P. F.R.S. |
| Peter Carthew, Esq. | William Pinney, Esq. M.P. |
| Stephen Martin Leake, Esq. | John White, Esq. |

were duly *elected* Members of the Royal Institution.

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| De Burgh Birch, M.D. | C. W. Stokes, Esq. |
| W. Ernst Browning, Esq. | John N. Tweedy, Esq. |
| Alexander Duncan, Esq. | Alexander Williamson, Esq. |
| John Line, Esq. | |

were duly *admitted* Members of the Royal Institution.

The following PRESENTS were announced, and the thanks of the Members ordered to be returned for the same:—

FROM

*Anderdon, J. L. Esq. (the Author)*—The River Dove, with some quiet thoughts on the happy practice of Angling. 16mo. 1847.

*Anderson, W. J. Esq., F.R.C.S., M.R.I. (the Author)*—Hysterical and Nervous Affections of Women. 12mo. 1853.

*Anonymous*—Reports to the Senate of the United States on Colt's Repeating Pistols. 8vo. 1851.

Report to the Congress of the United States on Dr. Morton's Memorial asking for remuneration for the discovery of the anæsthetic or pain-subduing properties of Sulphuric Ether. 8vo. 1852.

*Astronomical Society, Royal*—Monthly Notices, Vol. XIII. No. 3. 8vo. 1853.

*Author*—Observations on India, by a Resident there many years. 8vo. 1853.

*British Museum, Trustees of the*—List of the Specimens of the British Animals, Parts 6-12. 12mo. 1851-2.

Catalogue of Mammalia, Part 3. 12mo. 1852.

List of Homopterous Insects, Parts 2, 3, 4. 12mo. 1851-2.

List of Hemipterous Insects, Parts 1, 2. 12mo. 1851-2.

Nomenclature of Coleopterous Insects. Part 6. 12mo. 1852.

List of Coleopterous Insects. Part 1. 12mo. 1851.

List of Fish, Part 1. 12mo. 1851.

Catalogue of Phaneropneumona, or Terrestrial Operculated Mollusca. 12mo. 1852.

Catalogue of Mollusca. Part 4. 12mo. 1853.

Catalogue of Neuropterous Insects. Part 1. 12mo. 1852.

Catalogue of Marine Polyzoa, Part 1. 12mo. 1852.

Catalogue of Lepidopterous Insects, Part 1. 4to. 1852.

Fragments of the Iliad of Homer from a Syriac Palimpsest. Edited by W. Cureton, M.A. 4to. 1851.

Catalogue of the Greek and Etruscan Vases in the British Museum, Vol. I. 8vo. 1851.

Catalogus Codicum Manuscriptorum Orientalium qui in Museo Britannico asservantur. Pars II. Codices Arabices amplectens. fol. 1852.

*Bromfield, Miss Eliza (through J. Ivatt Briscoe, Esq., M.R.I.)*—Part of the Library of her brother, the late Dr. BROMFIELD, viz.:—

Antonio de Herrera, Descripcion de las Indias Occidentales;—y Historia General de los Hechos de los Castellanos en las Islas y Terra-Firme de el Mar Oceano. 4 vols. fol. Madrid, 1730.

Antonio de Solis, Historia de Conquista de Mexico. &c. fol. Barcelona, 1711.

Shaw's Abridgement of Boyle's Works. 3 vols. 4to. 1725.

Petri Martyris ab Angleriâ Mediolanensis de Rebus Oceanicis et Orbe Novo Decades III.; ejusdem Legationis Babylonicæ Libri III. fol. Basileæ, 1533.

The Sceptical Chemist. 8vo. 1680.

Johann Kunckels Laboratorium Chymicum. 8vo. Hamburg, 1722.

C. Linnæi Species Plantarum. 2 vols. 8vo. Holmiæ, 1762-3.

Dictionnaire Français-Italien et Italien-Français, par F. D'Alberti. 2 vol. 4to. Milan, 1826-8.

C. Delén, English and Swedish Lexicon. 4to. Stockholm, 1806.

G. N. Landré et P. Agron, Dictionnaire Français-Hollandais, et Hollandais-Français. 2 vols. 12mo. Amsterdam, 1828.

System of Chemistry of Inorganic Bodies, by T. Thomson. 2 vol. 8vo. 1831.

Elementary Introduction to Mineralogy, by W. Phillips, F.L.S. 8vo. 1823.

Reise in Chile, Peru, und auf dem Amazonstrome, während der Jahre 1827-32, von E. Poeppig. 3 vols. 4to. Leipzig, 1835-6.

Versuch einer Beschreibung von St. Petersburg, von J. G. Georgi. 8vo. St. Petersburg, 1790.

*East India Company, Hon.*—A Dictionary, English and Sanskrit, by Monier Williams, M.A. 4to. 1851.

A Dictionary, Persian, Arabic, and English, by Francis Johnson. 4to. 1852.

The Gulistán (Rose-Garden) of Shekh Sâdí of Shíráz. A new edition carefully collated with original MSS., by E. B. Eastwick, M.R.A.S. 8vo. 1850.

Anvăr-i Suheli, or the Lights of Canopus, being the Persian version of the Fables of Bidpăi, by Husain Vaiz Kăshifi. Edited by Lieut.-Col. J. W. J. Ouseley. 4to. 1851.

The Prem Ságar, or the Ocean of Love; being a History of Krishn; translated into the Hindí by Lallú Lál. A new edition, with a Vocabulary, by E. B. Eastwick, M.R.A.S. 8vo. 1851.

*Faraday, M. Esq., F.R.S., &c.*—Monatsbericht der Königl. Preuss. Akademie, Jan. 1853. 8vo.

*Franklin Institute of Pennsylvania*—Journal, Vol. XXIV. No. 2. 8vo. 1852.

*Londesborough, The Lord, K.C.H., M.R.I.*—Catalogue of a Collection of Ancient and Mediæval Rings and Personal Ornaments formed for Lady Londesborough. [By T. Crofton Croker, Esq.] (Privately Printed.) 4to. 1853.

*Lovell, E. B. Esq., M.R.I. (the Editor)*—The Monthly Digest for March, 1853. 8vo.

*Manning, Frederick, Esq., M.R.I.*—Map of the Soke of Grantham.

*Moon, Robert, Esq., M.A. (the Author)*—Light explained on the Hypothesis of the Ethereal Medium being a Viscous Fluid. Part I. 8vo. 1853.

*Noad, Henry, Ph.D., M.R.I. (the Author)*—Chemical Manipulation and Analysis, Qualitative and Quantitative; with an Introduction. New Edition. 8vo. 1852.

*Photographic Society*—Journal, No. 1. 8vo. 1853.

*Manning, Frederick, Esq., M.R.I.*—Cast of Cypher of Charles Cotton and Izaak Walton, over the door of the Fishing-house of Charles Cotton, near Beresford-Hall, Staffordshire.

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## WEEKLY EVENING MEETING,

Friday, April 8.

SIR CHARLES FELLOWS, Vice-President, in the Chair.

REV. W. TAYLOR, F.R.S.*

### *Observations on different Modes of Educating the Blind.*

THE Lecturer feeling that he was working in the cause of the blind, hoped that the importance of the subject would atone, in some degree at least, for the imperfect manner in which he should bring it before his audience; and that his want of skill as a lecturer would

[* Editor of "Diagrams of Euclid, Book I." and "Select Psalm-tunes," both embossed for the use of the Blind; and author of "Report to the Royal Scottish Society of Arts on the various Alphabets proposed for the use of the Blind," and of a Report on Printing for the Blind, published by the British Association in their Seventh Report.]

not injure the great cause, which he had for more than thirty years laboured to promote.

France had the great merit of having established the first school for the blind, which was founded by Valentine Haüy, at Paris, in the year 1784. This example, some seven or eight years after, was followed by Liverpool, Bristol, London, &c.; but it is supposed that there are more schools, &c. for the blind in the different German states than in all the known world besides.

That the blind, like others, as rational beings, have a claim to be educated, is beyond a doubt. But the amount of education they are capable of, must depend upon many things. Till within about sixty or seventy years, the blind were thought incapable of learning anything; now however experience has shewn that there is scarcely any branch of education beyond their reach. All blind persons, except idiots, may be taught enough to lessen their affliction, if not to make them useful and happy.

It was also thought that this portion of instruction could be acquired only in institutions for the blind, where helps and tools adapted to their case, are provided; but, now they are better understood, they may be, *partially* if not *wholly*, educated in their own family circle; and through the help of various ingenious contrivances used in teaching the blind, the difference between them and those who see, is reduced almost to a minimum.

The Blind may be divided into various classes, viz: — Such as are born blind; those who have become blind in after life; those who are totally blind; and those who have a glimmer of sight. These may again be subdivided into males and females; young and old; rich and poor; and lastly, such as are deaf and dumb as well as blind.

Those who are *born blind* are very few indeed. Most who are thought to be so have lost their sight soon after birth, generally from inflammation brought on either from careless or injudicious exposure to the light or cold; but now, from the improved manner of treating this disease, it does not so often terminate in blindness as it formerly did. Moreover the facility of procuring medical aid, by the poor, in such cases, is much greater than it was some years ago, and they are more inclined to seek it. These, together with the introduction of vaccination, have greatly lessened the proportion of those who are blind to those who see, not only in this country, but also in many others — so that, from some statistical enquiries made in Austria, Prussia, the canton of Zurich, &c., the blind in those localities may be about one in 1500 or 1600, and in England perhaps less. In Egypt it is said to be very much greater—even one in 200.*

Those who possess a glimmer of sight, sufficient to enable them to avoid posts and other obstacles, are useful in an institution, as guides to others, but their small portion of vision is seldom of any use to them in learning a trade, &c.

* "Volney says of every hundred you meet in the streets of Cairo twenty will be blind and thirty more with defective sight."

On the Continent, and in some English schools, the proportion of males to females is nearly as two to one. This arises perhaps from boys being more exposed to accidents than girls, in their occupations, &c. There are many more ways of gaining a livelihood open to the males than to the females; they are, therefore, more easily provided for, when they leave an institution. They may learn basket-making, weaving, rope-making, and many other trades; the females however learn to knit, sew, spin, net, crochet, plait hair, straw, &c., make sash-cord, fringe, paper boxes for jewellers, hatters, druggists, &c.; and should be taught household work. All may learn to read embossed characters and to write.

For the blind, who are incapable of working, from age or otherwise, especially the females, an additional number of asylums is much needed. There is also much wanted a college or school for the blind of the wealthier classes, where they could be educated amongst those of their own rank in life. If such an institution were once established and properly officered, there is no doubt of its being well supported, as there are many parents who would not object to pay liberally for the advantage of having their blind children regularly educated in an establishment of that kind, where they would have the opportunity of being instructed in the higher branches of knowledge. That these are within their reach, has been proved by Blacklock, Baczko, Knie, Saunderson, Weissenburg, Huber, Gough, Paradies, Milton, Moyes, Pfeffel, Käferle, and many others.— Modelling in clay, wax, &c., and sculpture, carving in wood, and even engraving, have all been accomplished by the blind. Amusements such as chess and other games are also most desirable for them, as they feel a delight in not being dependent upon the seeing either for their employments or their pleasures. The poorer blind should have some mental cultivation as well as mechanical; for a certain quantity of the former makes the acquirement of the latter more easy. All blind persons would derive great advantage from being well drilled in Arithmetic. It is an admirable exercise for the mind — enables them to arrange their ideas, furnishes them with amusement, and renders them more apt at acquiring other kinds of information.

There is another class of our fellow creatures who have a large claim upon our sympathy and benevolence — those who, in addition to their *blindness*, are *deaf and dumb*. One of the most remarkable of these is Laura Bridgeman, of Boston in America, who has been some years under the care of the famous Dr. Howe, and whose case is related by Dr. Kitto in his book "On the Lost Senses," in which he states that she had acquired some knowledge not only of things around her, but also of God and Religion. She writes a good hand and expresses her ideas in language which would not disgrace one in possession of his five senses.* There is a blind, deaf

* In the Second Volume of the Smithsonian Contributions to Knowledge is a Paper by F. Lieber on the Vocal Sounds of Laura Bridgeman, with a fac-simile letter.

and dumb person, in the workhouse at Rotherhithe, one at Bath, two at Lausanne, &c.

There is a similar case at Bruges under the care of that great friend to the blind, the Abbé Carton. When seen by the Lecturer, she was about twenty-two years of age, had been in the school not a year, and yet had learned to knit even fancy work although she had only three senses remaining. He gave her the letter O, embossed on a bit of card; she shewed that she knew it by making her mouth circular and drawing her finger round it. Other letters were variously designated. When she wanted coffee she imitated the grinding of it by turning her hand as if she had the mill. The Lecturer wished to see her knit. She objected to that as it was a saint's day, which she denoted by shewing that she had her best clothes on, but intimated that if he would come on the morrow, (which she signified by laying her head on her hand, as if on a pillow) she would knit for him, &c. &c.

In the school at St. John's Wood there is a blind and deaf man who as yet retains his speech. He knows when the master comes into the room either by feeling the jar of his step or by his sense of smell. Communications are made to him by writing with the finger on his hand or back, and he very readily comprehends them. Here is a proof of the advantage of employing the common alphabet; for had he learned an arbitrary character very few could hold intercourse with him.

"Instructors of the blind should be strictly moral and heartily inclined, irrespective of trouble or reward, to promote the welfare of their pupils: they should have a fondness for children and for teaching — they should possess mildness, patience, kindness, sympathy, tranquillity, and perseverance, with a spirit of order and regularity. These are the moral principles or qualities to be desired in those who undertake the education of the blind. On the other hand they should have moderate learning, talent to impart it, and a certain acquaintance with the various branches of knowledge; for as their pupils cannot refer to books, the teacher must be everything to them.—It is easy to imagine that an *educated blind person* would be the best teacher of the blind, in such things as require a peculiar mode of treatment, especially in mechanical operations." (Klein.)

The Lecturer then explained some of the many ingenious contrivances used in teaching the blind. The first was a board of cork with a few pins and a string, which he considers very useful. The pins are stuck into the cork at the angles of any straight-lined diagram and the string passed round them, forming a figure which the blind can readily feel. If circles are wanted they may be made of wire or cut in pasteboard, &c.

The next was a mariner's compass without the glass, in order that the blind may feel the needle. After it has stood long enough to take its proper direction, it is fixed in that position by a small lever

that lifts it up against the rim, which is in diameter a little less than the length of the needle. This is very useful to the blind in going about by themselves in the country.

The Lecturer then explained a small chess-board with crooked pins for the men, by which the blind can play at chess with a person having the common board.—Each can be considering his game without interrupting the other, as the blind has no occasion to touch his adversary's board; of course each must name his move which the other copies.

Printing in embossed letters was next explained, and a blind girl of about 18, from the school at St. George's, readily deciphered a sentence printed by the Lecturer with a pen and thick ink. This tends to prove that the letters need not be in very high relief, and forms an easy means of communicating with them. She also read from a book embossed in the common Roman alphabet: and afterwards, a young man, from the school in St. John's Wood read from Lucas's stenographic characters and also the Roman capitals and small letters. The Lecturer said that much difference of opinion existed as to the best alphabet for the blind, some advocating an arbitrary character, some the Roman letters, and some a modification of one of them; but that he himself preferred the common Roman alphabet, capitals and small letters, and that he was supported in his opinion by Klein of Vienna, Dr. Zeune of Berlin, Knie of Breslau (himself blind and director of the school in that town), Jäger of Gmünd, Baczko (blind), &c. &c., all of whom had had from thirty to fifty years' experience. In this country also the Roman letters were preferred in the schools at Manchester, York, Bristol, and several others — also by Mr. Littledale of York, who having lost his sight when six years old, must be allowed to be a good judge.—The blind should be associated with the seeing as much as possible in all their habits and acquirements, but an arbitrary character tends to separate them, and make them as it were a colony of strangers in their own land. Besides if they have a book in an arbitrary character, and they come to a word they do not understand, who in a village could render them assistance? Who could read for them from their book, when they were tired? Who could communicate with them should they become deaf as well as blind? Almost every alphabet may possess some *single* advantage over others, but the one to be chosen for the blind should be that which possesses the *greatest number* of advantages — or is best as a *whole*. Unfortunately, in comparing alphabets, care is not taken to have them printed the same *size* and same distance apart, and then the comparison is worthless.

It is the opinion of the Lecturer that children should be *educated* by means of the *common* alphabet, and if they like afterwards to learn any other on account of some supposed or real advantage it may possess, they might do so. Many blind persons derive much amusement by going into churchyards and reading the grave-stones, but of course only those who have learned the common letters. It

should be something very superior, indeed, to induce us to depart from the *ordinary* alphabet, and nothing of that kind has yet come to the notice of the Lecturer, although he has examined many systems and heard many able advocates of them, but without altering his own opinion, which every day's experience tends to strengthen. One great mistake in considering which is the best system for the blind is, that the *blind themselves are not sufficiently consulted*, for *they are the best judges after all;* and in the end, when they have had a fair chance, will decide the question better than the seeing can for them.

The Arithmetic boards were also exhibited and explained. They consisted of holes into which little pegs were put to represent the different figures. One had pentagonal holes, and pegs with a single projection at one end to represent the five odd numbers, and two projections at the other end to denote the five even numbers. The other board had saw-cuts across it so as to divide it into squares of about $\frac{1}{4}$ of an inch each, in the centre of which was a hole of $\frac{1}{8}$ of an inch square into which square pegs were put; but as these would represent only eight numerals, other pegs were added with differently formed ends which served for the other two numerals, and for algebra; into the saw-cuts bits of tin were placed to divide fractions, serve as vincula, denote roots, powers, &c.

When at the Blind School in Berlin, the Lecturer put the following question in arithmetic to the pupils, which was very soon solved *mentally*. If 10 men can dig a trench 70 yds. long, 3 wide, and 2 deep in 36 days of 9 hours each; how many men will it require to dig one 60 yds. long, 4 wide, and 5 deep, in 40 days of 10 hours each? The Lecturer also worked out the sum with his pencil: but the answers did not agree, one being $23\frac{1}{7}$ and the other $23\frac{1}{8}$. One boy contended that *he* was right, and on going over the work again he proved to be correct. Many similar questions were often put to the York pupils at their public examinations, and were readily answered by means of the board and pegs, even by boys of eleven or twelve years old.

A young man who had learned basketmaking in the York school, was also employed by the Mechanics' Institute to attend there certain nights in the week to instruct a class in algebra and geometry, a knowledge of which he had acquired partly in the school, and partly after he left. In his trade he employed a blind companion as a journeyman to whom he paid from eleven to fourteen shillings a week.

The Lecturer then explained a simple but ingenious portable printing machine by which the blind can communicate with one another or with the seeing. He said it was the cleverest, most easily learnt, least liable to get out of order, quickest in operation, and cheapest he had ever seen. It was invented by Mr. Littledale of York. One of its great advantages is that it embosses *upwards*, so that what has been done may be readily examined by the finger without moving the paper, and any alphabet may be used in it.

The Music board came next. It is about three feet long and about ten inches wide, having raised lines upon it running from one end to the other. Ten of them are flat on the top and represent the five lines of the treble and of the bass: one line between the bass and treble, two below the bass, and three above the treble, are round on the top and represent the leger lines. Both the lines and spaces are pierced with small holes $\frac{1}{4}$ of an inch apart, into which pins variously crooked to represent the different notes, are placed — these pins the blind can make for themselves — a pin with the head on represents a *note*,— one crooked in the same way but having the head taken off stands for the *rest* of that note, &c. Between the holes are saw-cuts all across the board into which bits of tin or pasteboard are placed to serve as bars. So that any piece of music may be written upon it. It is very advantageous in teaching thorough bass, as every note in the chord may be set down; and if the master leave a certain bass on the board as a lesson, the pupil may, *in his absence*, study and harmonize it, and the master can afterwards correct it. *Oral* instruction ends when the master leaves his pupil — therefore much time is gained by the board. It is much used and with great advantage in the York school. It was invented in Paris, but improved by Mr. Littledale.

One of the numbers of the "Magazine for the Blind" was shewn. This publication in embossed Roman letters was edited and printed by Mr. Lambert, a gentleman then living in York, who had been blind from infancy. It continued two years, but was given up on account of the expense. It is a great pity that it was not better supported, as the blind took intense interest in it. The price was sixpence, but now could be printed for much less.

A little box was produced, which had been turned, in presence of the Lecturer, by one of the blind boys in the York school, and which would have been no mean piece of work for a beginner who had sight. The boy had had only three or four lessons.

A specimen of Berlin work, executed by Mr. Littledale as an amusement, was also shewn, and several other things.

A simple writing frame was next explained, which consisted of a piece of mill-board about ten inches square, to which was attached, by hinges, a brass frame having a number of holes in two of its opposite sides; through these a string of catgut was put which formed lines in pairs across the frame. The pairs of lines were about $\frac{1}{2}$ an inch apart and the lines in each pair $\frac{1}{8}$. To use it, place a sheet of paper on the board, and upon this a sheet of tracing paper, black on the side next to the writing paper; shut the frame, and with a stile or blunt point write between the narrow lines which will give way for the tops and tails of the letters. This was invented at Paris.

The Lecturer stated that his thanks were due to the Viscount Cranborne, to the Society of Arts, to the Committee, of the Blind Schools at St. George's Southwark, and at York, and to W. D.

Littledale, Esq. for the loan of various books, maps, and apparatus for teaching the blind, and for specimens of their work.

The Lecturer recommended the following General Rules for the management or treatment of the Blind, derived from his own experience and the works of Klein, Zeune, Knie, Baczko, Orell, Jäger, Struve, and others.

1. It is of the greatest importance that blind children be religiously brought up, for as they are deprived of many pleasures and advantages which the seeing enjoy, they have the greater need of the promises and consolations of Religion. But it must be remembered that Religion, like powerful medicine, should be administered with the greatest judgement.
2. They should be treated as much like the seeing as possible, so as to render social intercourse with them agreeable and beneficial, and conducive to the strengthening of their four remaining senses.
3. Amongst the various contrivances for facilitating the education of the blind, choose the *simplest*, and such as are in use with the seeing, when they are sufficient for your purpose.
4. Never assist them further than is necessary, in order to teach them to help themselves. Encourage them to examine every thing that comes in their way, and to ask questions.
5. From their earliest years accustom them to *activity*, even if it be only for amusement — it will prevent their brooding over their misfortune, which not only injures their health, but renders them unfit for mental or bodily exertion.
6. Avoid, in their presence, giving utterance to feelings of pity or commiseration for their misfortune, as it only serves to remind them of their situation and gives them pain.
7. In conversing with the blind you need not avoid such subjects as relate to vision, &c. for from frequently hearing those things described, they will form very good notions concerning them, and their lively imaginations will supply their minds with useful representations of them.
8. You need not be much troubled about any little hurt they may receive from running against chairs, tables, &c. or in using certain tools, as such trifling accidents teach them caution and prevent greater.
9. In moving about a room, &c. should they take a wrong direction, it is well to set them right *privately* and avoid as much as possible doing or saying anything to make them feel their dependence upon those who have their sight.
10. Be ever careful not to *deceive* the blind — even though you should think it for their good, for you will never regain their confidence, and it will tend to make them suspect others. Besides it is not so easy to deceive them as may be imagined, for having to depend upon four senses to do the duty of five, their discern-

ment acquires a degree of acuteness beyond that of the seeing, which is very advantageous to them in their education.

11. When you meet blind persons whom you intend to address, always make yourself known to them by mentioning your name, till your voice becomes familiar to them — it spares them the unpleasantness of doubt and confusion.
12. Be careful how you *watch* the blind, unobserved as you may think, lest by their smelling or hearing, they detect you, and in that case you will forfeit their good opinion.
13. When you ask a blind person a question and he gives you an answer, always signify your agreement or disagreement with it, for if you go away in silence he is sometimes in doubt whether or not you are displeased. A touch of the finger on the shoulder or hand is to them what a smile is to the seeing.
14. You should ask a blind person if he has *seen* this or that thing? or if he has *read* this or that book instead of saying "*felt,*" &c., which would remind him of his misfortune.*

[W. T.]

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## WEEKLY EVENING MEETING,

Friday, April 15.

SIR CHARLES FELLOWS, Vice-President, in the Chair.

THOMAS H. HUXLEY, Esq. F.R.S.

*On the Identity of Structure of Plants and Animals.*

THE Lecturer commenced by referring to his endeavours last year to shew that the distinction between living creatures and those which do not live, consists in the fact, that while the latter tend to remain as they are, unless the operation of some external cause effect a change in their condition, the former have no such inertia, but pass spontaneously through a definite succession of states — different in kind and order of succession, for different species, but always identical in the members of the same species.

There is however another character of living bodies — *Organization*; which is usually supposed to be their most striking peculiarity, as

* Some excellent matter on this subject may be found in an English translation of Dr. Guillie's Book on the Blind, and also in the article "BLIND" in the last Edition of the Encyclopædia Britannica, and in the Penny Cyclopædia.

contrasted with beings which do not live; and it was to the essential nature of organization that the Lecturer on the present occasion desired to direct attention.

An organized body does not necessarily possess organs in the physiological sense—parts that is, which discharge some function necessary to the maintenance of the whole. Neither the germ nor the lowest animals and plants possess organs in this sense, and yet they are organized.

It is not mere external form, again, which constitutes organization. On the table there was a lead-tree (as it is called) which, a mere product of crystallization, possessed the complicated and graceful form of a delicate Fern. If a section were made of one of the leaflets of this tree, it would be found to possess a structure optically and chemically homogeneous throughout.

Make a section of any young portion of a true plant, and the result will be very different. It will be found to be neither chemically nor optically homogeneous, but to be composed of small definite masses containing a large quantity of nitrogen, imbedded in a homogeneous matrix having a very different chemical composition; containing in fact abundance of a peculiar substance—*Cellulose*.

The nitrogenous bodies may be more or less solid or vesicular—and they may or may not be distinguished into a central mass (*nucleus* of Authors) and a peripheral portion (*Contents, Primordial utricle* of Authors)—on account of the confusion in the existing nomenclature, the Lecturer proposed the term *Endoplasts* for them.

The cellulose matrix, though at first unquestionably a homogeneous continuous substance, readily breaks up into definite portions surrounding each Endoplast;—and these portions have therefore conveniently, though, as the Lecturer considered, erroneously, been considered to be independent entities under the name of Cells:—these, by their union, and by the excretion of a hypothetical intercellular substance, being supposed to build up the matrix. On the other hand, the Lecturer endeavoured to shew that the existence of separate cells is purely imaginary, and that the possibility of breaking up the tissue of a plant into such bodies, depends simply upon the mode in which certain chemical and physical differences have arisen in the primarily homogeneous matrix, to which, in contradistinction to the Endoplast, he proposed to give the name of *periplast* or *periplastic substance*.

In all young animal tissues the structure is essentially the same, consisting of a homogeneous periplastic substance with imbedded Endoplasts (*nuclei* of Authors); as the Lecturer illustrated by reference to diagrams of young Cartilage, Connective tissue, Muscle, Epithelium, &c. &c.; and he therefore drew the conclusion that the common structural character of living bodies, as opposed to those which do not live, is the existence in the former of a local physico-chemical differentiation; while the latter are physically and chemically homogeneous throughout.

These facts, in their general outlines, have been well known

since the promulgation, in 1838, of the celebrated Cell-theory of Schwann. Admitting to the fullest extent the service which this theory had done in Anatomy and Physiology, the Lecturer endeavoured to shew that it was nevertheless infected by a fundamental error, which had introduced confusion into all later attempts to compare the vegetable with the animal tissues. This error arose from the circumstance that when Schwann wrote, the primordial utricle in the vegetable-cell was unknown. Schwann, therefore, who started in his comparison of Animal with Vegetable Tissues from the structure of Cartilage, supposed that the corpuscle of the cartilage cavity was homologous with the "nucleus" of the vegetable cell, and that therefore all bodies in animal tissues, homologous with the cartilage corpuscles, were "nuclei." The latter conclusion is a necessary result of the premises, and therefore the Lecturer stated that he had carefully re-examined the structure of Cartilage, in order to determine which of its elements corresponded with the primordial utricle of the plant, — the important missing structure of which Schwann had given no account: — working subsequently from Cartilage to the different tissues with which it may be traced into direct or indirect continuity, and thus ascertaining the same point for them.

The general result of these investigations may be thus expressed: —*In all the animal tissues the so called nucleus* (Endoplast) *is the homologue of the primordial utricle* (*with nucleus and contents*) (Endoplast) *of the Plant, the other histological elements being invariably modifications of the periplastic substance.*

Upon this view we find that all the discrepancies which had appeared to exist between the Animal and Vegetable Structures disappear, and it becomes easy to trace the *absolute identity* of plan in the two, — the differences between them being produced merely by the nature and form of the deposits in, or modifications of, the periplastic substance.

Thus in the Plant, the Endoplast of the young tissue becomes a "primordial utricle," in which a central mass, the "nucleus," may or may not arise; persisting for a longer or for a shorter time, it may grow, divide and subdivide, but it never (?) becomes metamorphosed into any kind of tissue.

The periplastic substance follows to some extent the changes of the endoplast, inasmuch as it generally, though not always, grows in when the latter has divided, so as to separate the two newly formed portions from one another; but it must be carefully borne in mind, though it is a point which has been greatly overlooked, that it undergoes its own peculiar metamorphoses quite independently of the endoplast. —This the Lecturer illustrated by the striking case of the Sphagnum leaf, in which the peculiarly thickened cells can be shewn to acquire their thickening fibre *after the total disappearance of the primordial utricle,* — and he further quoted M. von Möhl's observations as to the early disappearance of the pri-

mordial utricle in woody cells in general,—in confirmation of the same views.

Now, these metamorphoses of the periplastic substance are two-fold: 1. Chemical, 2. Morphological.

The Chemical changes may consist in the conversion of the cellulose into xylogen, &c. &c. or in the deposit of salts, silica, &c. in the periplastic substance. Again, the periplastic substance around each endoplast may remain of one chemical composition, or it may be different in the outer part (so-called intercellular substance) from what it is in the inner (so-called cell-wall).

As to Morphological changes in the periplastic substance, they consist either in the development of cavities in its substance—*vacuolation* (development of so-called intercellular passages) or in *fibrillation* (spiral fibres, &c.).

It is precisely the same in the Animal.

The Endoplast may here become differentiated into a nucleus and a primordial utricle (as sometimes in Cartilage) or more usually it does not,—one or two small solid particles merely arising or existing from the first, as the so-called "*nucleoli;*"—it persists for a longer or shorter time; it divides and subdivides, but it never (except perhaps in the case of the spermatozoa and the thread-cells of Medusæ, &c.) becomes metamorphosed into any tissue.

The periplastic substance, on the other hand, undergoes quite independent modifications. By chemical change or deposit it acquires Horn, Collagen, Chondrin, Syntonin, Fats, Calcareous Salts, according as it becomes Epithelium, Connective Tissue, Cartilage, Muscle, Nerve or Bone, and in some cases the chemical change in the immediate neighbourhood of the endoplast is different from that which has taken place exteriorly,—so that the one portion becomes separable from the other by chemical or mechanical means; —whence, for instance, has arisen the assumption of distinct walls for the bone-lacunæ and cartilage-cavities; of cell-contents and of intercellular substance as distinct histological elements.

The Morphological changes in the periplastic substance of the animal, again, are of the same nature as in the plant:—Vacuolation and Fibrillation (by which latter term is understood, not only the actual breaking up of a tissue in definite lines, but the tendency to do so)—*Vacuolation* of the periplastic substance is seen to its greatest extent in the "Areolar" connective tissue;—*Fibrillation* in tendons, fibro-cartilages and muscles.

In both Plants and Animals, then, there is one histological element, the Endoplast, which does nothing but grow and vegetatively repeat itself; the other element, the periplastic substance, being the subject of all the chemical and morphological metamorphoses, in consequence of which specific Tissues arise. The differences between the two kingdoms are, mainly, 1. That in the Plant the Endoplast grows, and, as the primordial utricle, attains a large comparative size;—while in the Animal the Endoplast remains small,

the principal bulk of its tissues being formed by the periplastic substance; and, 2; in the nature of the chemical changes which take place in the periplastic substance in each case. This distinction however does not always hold good, the Ascidians furnishing examples of animals whose periplastic substance contains cellulose.

"The Plant, then, is an Animal confined in a wooden case, and Nature, like Sycorax, holds thousands of 'delicate Ariels' imprisoned within every Oak. She is jealous of letting us know this, and, among the higher and more conspicuous forms of Plants, reveals it only by such obscure manifestations as the shrinking of the Sensitive Plant, the sudden clasp of the Dionœa, or, still more slightly, by the phenomena of the Cyclosis. But among the immense variety of creatures which belong to the invisible world, she allows more liberty to her Dryads; and the Protococci, the Volvox, and indeed all the Algæ, are, during one period of their existence, as active as animals of a like grade in the scale. True, they are doomed eventually to shut themselves up within their wooden cages and remain quiescent, but in this respect they are no worse off than the Polype, or the Oyster even."

In conclusion, the Lecturer stated his opinion that the Cell-theory of Schwann consists of two portions of very unequal value, the one anatomical, the other physiological. So far as it was based upon an ultimate analysis of living beings and was an exhaustive expression of their anatomy, so far will it take its place among the great advances in Science. But its value is purely anatomical, and the attempts which have been made by its author, and by others, to base upon it some explanation of the Physiological phenomena of living beings by the assumption of Cell-force, Metabolic-force, &c. &c. cannot be said to be much more philosophical than the old notions of "the actions of the vessels," of which physiologists have lately taken so much pains to rid themselves.

"The living body has often, and justly, been called, 'the House we live in;'— suppose that one, ignorant of the mode in which a house is built, were to pull it to pieces, and find it to be composed of bricks and mortar, — would it be very philosophical on his part to suppose that the house was built by *brick-force?* But this is just what has been done with the human body. — We have broken it up into 'cells,' and now we account for its genesis by cell-force."

[T. H. H.]

## WEEKLY EVENING MEETING,

Friday, April 22.

SIR CHARLES FELLOWS, Vice-President, in the Chair.

JOHN CONOLLY, M. D.

*On the Past and Present Condition of the Insane, and the Characters of Insanity.*

[DR. CONOLLY has been unavoidably prevented from supplying an abstract of his discourse.]

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## WEEKLY EVENING MEETING,

Friday, April 29th.

SIR CHARLES FELLOWS, Vice-President, in the Chair.

W. BROCKEDON, ESQ., F.R.S.

*On the treatment of Foreign Wines and the extensive injuries recently caused by a Fungus on the Grape.*

MR. BROCKEDON stated that his original intention had been to mention only such facts as had formerly come under his observation in certain wine districts in France, as to the treatment of wines, more especially those of Champagne, but that the fatal malady which was now desolating the vineyards of France and which had last year been observed by him, would form a painful part of his communication.

In the year 1842, he had been induced to visit Champagne and Bordeaux, and again in 1843 the former district, to recommend to the wine-merchants a trial of his patented mode of securing wine in bottles by means not liable to injury by insects or climate.

A stay of some weeks, at different seasons, in his visit to Champagne, enabled him to observe the treatment of the valuable product of the district, and to visit the principal vineyards and establishments at Epernay, Rheims, and Chalons-sur-Marne, during the vintage and the spring following.

Mr. Brockedon exposed the common error that the wine of Champagne was made of unripe fruit, an idea which must have

been suggested by our miserable attempt to imitate it with green gooseberries. The fact is that a more delicious fruit than the Champagne grape can scarcely be found, or more highly saccharine.

The finest wines are made by the most skilful merchants, who combine the growth of vineyards which differ in aspect, soil, and variety of the vines. The most famous of the vineyards, those of Ay, would yield for such mixture, one of the most valuable sorts to give quality to wine, but which alone would be far inferior to that which can be obtained by a judicious use of it in combination, by which flavour and strength are obtained, suited to the different markets; strong and full flavoured for England, sweet and highly effervescent for Russia, &c. Wine is impure when it is coloured, drugged, and flavoured artificially: admixtures of gooseberrry and rhubarb juices are unknown in Champagne.

The wine when pressed is not vatted in large quantities, but placed in casks which have been sulphured, to check fermentation and preserve its sweetness as far as possible. During the winter following the vintage, it is racked two or three times, and in the following spring, about March, the bottling commences.

In order to obtain the wine with perfect brightness, into each bottle is put a wine-glass full of *liqueur*, which is prepared by dissolving fine candied sugar in wine till it becomes a rich syrup. If the wine is to be made pink, a red wine is used; if pale, white wine. This liquor produces a fresh fermentation in the bottle, by converting the sugar into alcohol and carbonic acid gas. Every bottle on being filled and corked is laid on its side on a frame having holes made through it, into which the neck of the bottle is inserted. As the fermentation advances, every bottle in succession is dexterously shaken gently on its axis every day, to prevent any adhesive deposit on the side of the bottle; and each day it is lifted more and more upright in the frame until the foul portion rests only in the downward neck of the bottle. It is then ready for *dégorgement*, a process by which the foul deposit is removed. The bottle is carefully held in such a position, that when the string which holds the cork is cut, the deposit is blown out by the force of the gas within. The foul matter only is allowed to escape by the skilful use of the fore-finger of the operator, which stops the flow until the effervescence subsides under its pressure. He then quickly and dexterously fills up the bottle from the contents of another already purified. It is then passed with great rapidity under a machine, by which a large cork is forced into the bottle, and is then as rapidly tied. It is afterwards wired and stacked away in vast and cool caves, some of which, thousands of yards in extent, have been excavated in the solid chalk of the hill side. These stacks of bottled Champagne are so ingeniously made, that though they may each contain from 1000 to 10,000 bottles, any one of them can be withdrawn for examination. In a warm spring, the extent of bursting in these bottles is a cause of great loss. In April, 1843, Madame Cliquôt of Rheims lost

400,000 out of her stock for that season of 1,600,000 bottles. Further destruction was checked by obtaining from Paris ten or twelve waggon-loads of ice, which, strewn in the caves, lowered their temperature.

When the wine is thus stacked, the merchants visit the caves to buy, and it is scarcely recommended to their notice, unless the breakage can be shewn to be not less than ten per cent. It is this loss, and the cost of labour in preparing, that enhances so much the value of the wine of Champagne.

The condition of the wine in the bottle can be easily ascertained by a simple means. A fine hollow needle can be thrust through the cork, and a taste obtained from the pressure within, through the tube. On withdrawing the circular needle, the elasticity of the cork closes the puncture.

Of the quantity of champagne made, it is difficult to obtain accurate information; 50,000,000 bottles would be a low estimate for the genuine product of Champagne: but the demand for wines that effervesce is so great, that it is now supplied from the vineyards of St. Perey, Hermitage, Rhine, Moselle, Burgundy, Bordeaux, in fact from every wine district in which they choose to make it by sweetening and treating it as in Champagne.

But this is not the only mode of making champagne even with genuine French wine. Very large quantities are made in Paris and elsewhere; in that city there are numerous establishments for such manufacture; one house alone sending out 1,000,000 bottles a year. They sweeten the light common white wines of France, and then impregnate them with carbonic acid gas by means of a pneumatic apparatus, and bottle them, as in Champagne, while effervescent.

Mr. Brockedon gave little information upon the wines of Bordeaux, except to shew that the same skill in a judicious combination of the wines of neighbouring growths, gave the greatest celebrity to the most eminent of the wine establishments on the Garonne.

In the spring of 1845, a fungus on the grape was first observed in the hothouses of Mr. Slater of Margate, by his very intelligent and observant gardener, Mr. Edward Tucker, whose name has been given to it by the Rev. M. J. Berkeley, the eminent naturalist, viz. *Oidium Tuckeri*. It is an egg-shaped fungus, one of an immense family of this class of destroyers, but one not before known or recognized; and though it bears a close resemblance to those which are found upon the potato, peach, chrysanthemum, cucumber, groundsel, &c., yet it is distinguished from all others by a microscopic observer, and has never yet been found upon any other plant, and when found upon the grape has always been destructive. Its first appearance is like a whitish mildew, shewing itself principally upon the young grape when about the size of a pea.

When the spore of this fungus has settled on the young berry,

it enlarges and radiates irregularly in fine filaments, which often cover the whole surface, extending with great rapidity. These fix themselves by imperceptible attachments, which do not appear to penetrate the cuticle; numerous branches from the mycelium are unfruitful; others are jointed and rise vertically like the pile of velvet; the upper joint enlarges, rounds itself into an elliptical form, ripens, separates, and is carried off with the slightest motion of the air, to find another grape upon which it can be developed. Warmth and moisture favour its rapid fructification; a succession of spores rise from the same branch; and often two, three, or four, ripen and disperse almost at the same time. Its effect upon the grape is to exhaust the juices of the cuticle, which ceases to expand with the pulp of the fruit; it then bursts, dries up, and is utterly destroyed.

This fatal disease has returned with increased virulence in each succeeding year. In 1847, the spores of this *Oidium* reached France, and was found in the forcing-houses of Versailles and other places near Paris; but the disease soon reached the trellised vines, and destroyed the grapes out of doors in the neighbourhood, and continued to extend from place to place; but until 1850 it was chiefly observed in vineries, which lost from this cause, season after season, the whole of their crops.

Unhappily in 1851, it was found to have extended to the south and south-east of France and Italy, and the grapes were so affected that they either decayed, or the wine made from them was detestable.

In 1852, the *Oidium Tuckeri* reappeared in France with increased and fatal energy; it crossed the Mediterranean to Algeria, shewed itself in Syria and Asia Minor, attacked the Muscat grapes at Malaga, injured the vines in the Balearic Islands, utterly destroyed the vintage in Madeira, greatly injured it in the Greek Islands, and destroyed the currants in Zante and Cephalonia, rendering them almost unfit for use, and so diminished the supply, that 500 gatherers did the ordinary work of 8000 !

But it is in France that its frightful ravages are chiefly to be regarded as a national calamity, where the produce of the soil in wine is said to exceed 500 millions of hectolitres; two-fifths of the usual quantity of wine made there has been destroyed, and what has been made is bad. It has not touched with equal severity all the departments. Traces of its influence have been seen in the Loiret, Loire-et-Cher, and Maine-et-Loire. The vineyards of the Medoc in 1851 were untouched, and the cultivators laughed at the existence of the *Oidium;* but last year the disease shewed itself everywhere in the Gironde, even to the borders of the celebrated Medoc, and between the vineyards of the Medoc and the river at Pauillac and at Macau, with serious injury. In the Lower Pyrenees the wines of Jurançon were affected. The Haute Garonne was generally attacked; and at Toulouse one proprietor who usually sent to Paris 10,000

francs' worth of grapes for the table, lost all or nearly all by the *Oidium*. The Eastern Pyrenees, l'Aude, l'Herault, and a great part of Gard were all deplorably affected, and at Frontignan and Lunel the vineyards were abandoned in despair. Thousands of labourers were thrown out of employ, and the distress was awful. Wine in France is the common drink of the peasant; upon this, his bread, and some *legumes*, he labours; but the wine, bad as it is, has risen to double, and in the countries most injured even treble its ordinary price. In Lower Provence and on the Isère, the vines which escaped in 1851 were seriously injured in 1852. In the Burgundy district, the vines on the Côte d'Or were little affected in the vineyards, but the trellised vines were seriously so.

Many works have been published upon this most important subject. All the local papers, as the *Messager du Midi*, teem with letters and reports, and schemes (all failures) to stay the plague. In the "Atti dell' Accademia Pontificia," Professor P. Sanguinetti has published an essay, interesting only for the subject, but offering no remedy that has been found of any service to stay the evil.

Professor Möhl, in the *Botanische Zeitung*, has written an able paper translated by the Rev. Mr. Berkeley, and published in the Journal of the Horticultural Society for April, 1853. He gives a history of the development and diffusion of the disease, and reports to us its extension from France to the whole length of Italy by the coast of Liguria to Naples, then taking a retrograde course through the Tyrol to Botzen, overrunning Switzerland to Wintherthur, and touching certain spots in Baden, and in Wirtemburg and Hungary. M. Möhl has most carefully examined whether the *Oidium* of the grape lives on other plants besides the vine, but he is decidedly of opinion that it does not.

Some persons, as M. Robineau, have supposed that it was caused by insects, because occasionally they had been found on diseased vines: but the idea is now utterly rejected; for not the slightest appearance of disease precedes the fungus, which creeps over the epidermis but does not enter its tissues. It envelopes the grape, absorbs the juices of the superficial cells, and stops the growth of the cuticle. The pulp expands within the fruit, bursts longitudinally, its juices are lost, and it dries up. In an early stage of the disease the fungus may be wiped off, and the fruit will come to maturity. The *Oidium* never matures on decayed vegetable substances; it lives and fructifies only on living tissues.

The poor peasant of the Bouches du Rhone believes that the cause is bad air; but at Genoa, Grenoble, Lyons, Dijon, and Strasbourg, the people attribute it to gas-lights! and the vapour of locomotives!! and think that such inventions are infernal; and many works are published with such absurd imputations, and recommending preventives and remedies just as wise.

By far the ablest work upon this important subject is by M. Louis Leclerc, who, eminent as a man of science, was chosen by the

Minister of the Interior, M. Persigny, to go into the districts affected and to report upon the facts he could collect. This he has done in an admirable manner, and to his work, a brochure published in Paris, by Hatchette et C[ie]. Mr. Brockedon recommended his hearers, as containing all that can yet be said upon the subject. He reports the history of the scourge, exhibits its character, and relates what remedies have been tried, and what found successful.

The interest which the subject has excited in England has led to such extensive correspondence in the Gardener's Chronicle, that it contains not less than forty communications, and there are to be found the earliest notices of experiments made with lime-water, tobacco, lye of wood-ashes, &c. : — all these have failed. Mr. Kyle of Leighton discovered sulphur to be a sure remedy, and it is the only one yet known; but this, which can be applied in hot and green-houses cannot be used in large vineyards. House-grown grapes, if sulphur be puffed over the berries and vines, or if it be laid upon the pipes made damp in the hothouses, will vaporize and destroy the *Oidium* without injuring the fruit; but the sulphur must not be fired, or it will destroy the vines.

By many it is asked,— is the *Oidium* the cause or consequence of the disease of the vine?— The vine, one party says, is over-cultivated and liable to affections which the wild healthy plant resists, and it should be treated as in a state of plethora; tap it, lessen its sap, and it will invigorate so as to resist the poison of the *Oidium*. This has been tried, and failed. If this were the cause it could not have so suddenly and widely extended itself.

We can only hope that that Power which has created the *Oidium* may withdraw what to us appears to be so fearful a scourge.

[W. B.]

## ANNUAL MEETING.

Monday, May 2.

The Duke of Northumberland, K.G., F.R.S., President, in the Chair.

The Annual Report of the Committee of Visitors was read, and adopted.

Thanks were voted to the President, Treasurer, and Secretary, to the Committees of Managers and Visitors, and to Professor Faraday, for their services to the Institution during the past year.

The thanks of the Members were also voted to Dr. A. B. Granville for his past services as Honorary Secretary of the Board of Visitors for twenty-one years.

The following Gentlemen were unanimously elected as Officers for the ensuing year: —

President — The Duke of Northumberland, K.G. F.R.S.

Treasurer — William Pole, Esq. M.A. F.R.S.

Secretary — Rev. John Barlow, M.A. F.R.S.

### Managers.

William Wilberforce Bird, Esq.
Sir John P. Boileau, Bart., F.R.S.
John Bate Cardale, Esq.
Capt. Henry John Codrington, R.N.
George Dodd, Esq., F.S.A.
Sir Charles Fellows.
J. P. Gassiot, Esq., F.R.S.
Aaron Asher Goldsmid, Esq.
Henry Bence Jones, M.D., F.R.S.
George Macilwain, Esq.
George Moore, Esq., F.R.S., F.S.A.
Right Hon. Baron Parke.
Frederick Pollock, Esq., M.A.
Joseph William Thrupp, Esq.
Colonel Philip J. Yorke, F.R.S., Pres. Chem. Soc.

### Visitors.

J. G. Appold, Esq., F.R S.
J. J. Bigsby, M.D., F.G.S.
J. C. Burgoyne, Esq.
William Carpmael, Esq.
Alexander Crichton, Esq.
Thomas Davidson, Esq.
Edward M. Foxhall, Esq.
Sir John Hall, Bart., F.R.S.
John Hennen, M.D.
Edward Meryon, M.D.
John Carrick Moore, Esq., M.A.
William Roxburgh, M.D.
Rev. William Taylor, F.R.S.
Henry Twining, Esq.
Sir Richard R. Vyvyan, Bart., M. P., F.R.S., G.S.

## GENERAL MONTHLY MEETING,

Monday, May 9.

George Dodd, Esq., F.S.A., Vice-President, in the Chair.

John Burnett, Esq.
Edward Enfield, Esq.
W. Chas. Henry, M.D. F.R.S.
Edward Holland, Esq.
David Macloughlin, M.D., M.R.I.A., &c.
Charles Otter, Esq.
Geo. Taddy Tomlin, Esq., F.S.A.
Edwin Truman, Esq.
Frederic Weber, M.D.

were duly *elected* Members of the Royal Institution.

Peter A. Halkett, Esq. R. N.
Sir Jas. Matheson, Bt. M.P. F.R.S.
William Watt, Esq.

were duly *admitted* Members of the Royal Institution.

Thomas William Brande, Esq. F.R.S. L. & E. was unanimously re-elected Honorary Professor of Chemistry in the Royal Institution.

The following Presents were announced, and the thanks of the Members returned for the same;—

From

*Actuaries, Institute of*—The Assurance Magazine, and Journal of the Institute of Actuaries, No. 11. 8vo. 1853.
*Asiatic Society of Bengal*—Journal, No. 230. 8vo. 1852.
*Astronomical Society, Royal*—Monthly Notices, Vol. XIII. No. 4, 5. 8vo. 1853.
*Babbage, Charles, Esq. (the Author)*—Thoughts on the Principles of Taxation. 3rd Edition. 8vo. 1852.
*Bell, Jacob, Esq. M.R.I. (the Editor)*—The Pharmaceutical Journal for April and May, 1853. 8vo.
*Board of Admiralty*—Contributions to Astronomy and Geodesy. By T. Maclear, Esq., F.R.A.S. Second Series. 4to. 1853.
*Bombay, Medical Board*—Deaths in Bombay during 1851. 8vo. 1852.
*British Architects, Royal Institute of*—Proceedings for April, 1853. 4to.
*Chemical Society*—Quarterly Journal, No. 21. 8vo. 1853.
*Civil Engineers, Institution of*—Proceedings for April, 1853. 8vo.
*Cocks, Messrs. (the Publishers)*—Cocks' Musical Miscellany for April and and May, 1853. 4to.
*Council of Education, Calcutta*—General Report on Public Instruction in the Lower Provinces of the Bengal Presidency, 1851-2. 8vo. Calcutta, 1853.
*Cranborne, The Viscount (the Author)*—History of France, for Children. 16mo. 1853.
*East India Company, Hon.*—Magnetical and Meteorological Observations at Bombay in 1848. By Commander Montriou. 4to. 1852.

*Editors.* — The Medical Circular for April, 1853. 8vo.
The Athenæum for March and April, 1853. 4to.
The Practical Mechanic's Journal for April and May, 1853. 4to.

*Faraday Professor, F.R.S., &c.* — An Attempt to Establish the First Principles of Chemistry by Experiment. By Thomas Thomson. 2 vols. 8vo. 1825.
Memorie di Matematica e di Fisica della Società Italiana residente in Modena. Tomo XXV. Parte 1. 4to. Modena, 1852.
Die Lehre von der Reibungselektricität. Von P. T. Reiss, Dr. Phil. 2 vols. 8vo. Berlin, 1853.
Monatsbericht der Königl. Preuss. Akademie, Feb. 1853. 8vo.
Oversigt over det Kgl. Danske Videnskabernes Selskabs Forhandlinger og dets Medlemmers Arbeider, i Aaret, 1852. 8vo. Kjöbenhavn, 1852.
L'Académie des Sciences de Belgique: —
Bulletins des Séances de la Classe des Sciences. Années 1850-2. 8vo. Bruxelles, 1851-3.
Annuaire, 1851-3. 3 vols. 16mo. Bruxelles, 1851-3.

*Franklin Institute of Pennsylvania* — Journal, Vol. XXV. Nos. 2, 3, 8vo. 1853.

*Horticultural Society of London* — Journal, Vol. VIII. Part 2. 8vo. 1853.

*Johnson, Edmund C. Esq. (the Author)* — Tangible Typography; or How the Blind Read. 8vo. 1853.

*Königliche Bayerische Akademie der Wissenschaften* — Abhandlungen der Mathemat.-Physikalischen Classe. 6te Band, 1ste Abtheilung. 4to. München, 1851.
Annalen der Königlichen Sternwarte bei München, von Dr. J. Lamont. Band V. 8vo. München, 1852.

*Lee, Thomas, Esq. M.R.I.* — A Visit to Mexico by the West India Islands, Yucatan, and United States. By W. Parish Robertson. 2 vols. 12mo. 1853.

*Longman, Messrs., and Co.* — The Subject Matter of a Course of Six Lectures on the Non-Metallic Elements, by Professor Faraday. Arranged, by permission, from the Lecturer's Notes, by J. Scoffern. 16mo. 1853.

*Lovell, E. B. Esq., M.R.I. (the Editor)* — The Monthly Digest for April and May, 1853. 8vo.
The Common Law and Equity Reports in all the Courts. Edited by C. Wordsworth and E. B. Lovell, Esquires. Vol. I. Part 1. 8vo. 1853.

*Lubbock, John, Esq., F.Z.S., M.R.I., (the Author)* — On two new Sub-genera of Calanidæ, 8vo. 1853.

*Macloughlin, David, M.D. M.R.I. (the Author)* — Considération Médico-légale sur quelques signes de Paralysies Vraies et sur la Valeur relative. 8vo. Paris, 1845.
Reports from the General Board of Health on Quarantine. 8vo. 1849-52.
Report of the General Board of Health on the Epidemic Cholera of 1848-9. With the Appendices. 8vo. 1850-2.
Report on the Epidemic Cholera in Germany in 1852. By R. D. Grainger, 8vo. 1852.

*Morton, W. T. G., M.D. (the Author)* — Statements, supported by Evidence, of W. T. G. Morton, M.D. on his Claim to the Discovery of the Anæsthetic Properties of Ether. 8vo. 1853.

*Novello, Messrs. (the Publishers)* — The Musical Times, April and May, 1853. 4to.

*Prevost, M A. P. (the Author)* — Essai sur la Théorie de la Vision Binoculaire. 4to. Genève, 1843.

*Quetelet, M. Ad., M. de l'Inst. de France and Hon. M.R.I. (the Author)* — Sur le Climat de la Belgique. 4e et 5e parties. 4to. Bruxelles, 1851-2.
Rapport sur l'Observatoire Royal pendant 1852. 8vo. Bruxelles, 1853.

*Smith, Mr. J. Russell (the Publisher)* — The New Retrospective Review, No. 3. 8vo. 1853.

*Society of Arts* — Journal, Nos. 19—24. 8vo. 1853.

*Taylor, Rev. W., F.R.S., M.R.I. (the Author)* — Report to the British Association on the various Modes of Printing for the Blind. 8vo. 1838.
Report to the Royal Scottish Society of Arts on the best Alphabet and Method of Printing for the Blind. 8vo. 1837.

*Vereins zur Beförderung des Gewerbfleisses in Preussen* — Verhandlungen, Jan. und Feb. 1853. 4to. Berlin.
*Weale, John, Esq.* (*the Publisher*) — Rudimentary Treatises, 12mo. 1853:—
On the Power of Water. By Joseph Glynn, F.R.S.
Navigation and Nautical Astronomy. By H. W. Jeans, F.R.A.S.
Fuel. By T. S. Prideaux.
The Elements of Euclid, with additional Propositions and Notes, and an Introductory Essay on Logic. By H. Law, C. E. Part I. Books 1—3.

*Foxhall, Edward M., Esq., M.R.I.* — Portrait of Sir John Soane, one of the Original Proprietors of the Royal Institution.
*Langdon, Augustus, Esq.* — Specimens of Graphite in its Natural and Prepared Conditions.
*Spence and Dixon, Messrs., Pendleton, Manchester* — Specimens illustrating the Manufacture of Ammonia-Alum derived entirely from Coal and Coal Strata:—

No. 1. Alumina Coal Shale.
No. 2. The same calcined.
No. 3. Iron Pyrites as used for making Sulphuric Acid.
No. 4. Model of "Roaching Cask," one-fourth actual size, containing Alum Crystals ready for the market.

[FOR THE USE OF MEMBERS.]

# Royal Institution of Great Britain.

1853.

## WEEKLY EVENING MEETING,

Friday, May 6.

RIGHT HON. BARON PARKE, in the Chair.

DR. LYON PLAYFAIR, C.B., F.R.S.

*On the Food of Man under different Conditions of Age and Employment.*

THE Author commenced by adverting to our very imperfect acquaintance with the statistics of Food. We are still ignorant regarding the quantity of the different proximate constituents of Aliment necessary for Man's sustenance, even in his healthy and normal condition. If the question were asked — How much carbon should an adult man consume daily? — there would be scarcely more than one reliable answer, viz., that the soldiers of the body-guard of the Duke of Darmstadt eat about 11oz. * of carbon in the daily supply of food.

If again the question were asked — How much flesh-forming matter supports an adult man in a normal condition? — no positive answer could be given. Even, as respects the relation between the carbon in the flesh-forming matter and that of the heat-givers, we have no reliable information. It is true that certain theoretical conclusions on this head have been drawn from the composition of flour, but no real statistical answer deduced from actual experience exists.

When we inquire into the cause of our ignorance on these points, it is found that the progress to knowledge is surrounded with difficulties. Neither chemistry nor physiology is in a sufficiently advanced state to grapple satisfactorily with the subject of nutrition. For example, we know that albumen in an egg is the starting-point for a whole series of tissues; that out of the egg comes feathers, claws, fibrine, membranes, cells, blood corpuscules, nerves, &c., but only the result is known to us; the intermediate changes and their causes are quite unknown. After all, this is but a rude and unsatisfactory knowledge. Hence, when we approach the subject

* Liebig states it a higher amount, but this is a recalculation from the new food tables.

it is only to deal with very rough generalities. Admitting that the experience of man in diet is worth something, it is possible to arrive at some conclusions by the *statistical* method—that is, by accepting experience in diet and analyzing that experience. Take for example the one general line of Pauper Diet for the English counties placed in the table at the end of this notice. The mode of arriving at the result of experience, in the case of paupers, was to collect it from *every* workhouse in the kingdom, and then to reduce it to one line. But the labour of this is immense. In the preparation of this one line the following work had to be performed in acquiring the data.

| | |
|---|---|
| Number of Unions applied to . . . . . | 542 |
| Number of Explanatory letters sent to them . | 700 |
| Number of Calculations to reduce the results . | 47,696 |
| Number of Additions of the above calculations . | 6,868 |
| Number of Extra hours, *beyond the office hours*, paid to a Clerk for the reduction . . . . . | 1,248 |

The statistical method, besides being very laborious, is extremely tedious, and has thus deterred persons from encountering it. In giving, therefore, an example of some of the results which have been collected within the last few years, they will represent much labour, but very little or no originality.

The Lecturer then alluded shortly to the conditions in nutrition, which must be borne in mind in looking at these results. It was now admitted that the heat of the body was due to the combustion of the unazotised ingredients of food. Man inspires annually about 7 cwt. of oxygen, and about $\frac{1}{5}$th of this burns some constituent and produces heat. The whole carbon in the blood would thus be burned away in about three days, unless new fuel were introduced as food. The amount of food necessary depends upon the number of respirations, the rapidity of the pulsations, and the relative capacity of the lungs. Cold increases the number of respirations and heat diminishes them; and the Lecturer cited well known cases of the voracity of residents in Arctic Regions, although he admitted, as an anomaly, that the inhabitants of tropical climates often show a predilection for fatty or carbonaceous bodies. He then drew attention to the extraordinary records of Arctic Dietaries shown in the table, which, admitting that they are extreme cases, even in the Arctic Regions, are nevertheless very surprising.

Dr. Playfair then alluded to the second great class of food ingredients, viz., those of the same composition as flesh. Beccaria in 1742 pointed to the close resemblance between these ingredients of flesh, and asked "Is it not true that we are composed of the same substances which serve as our nourishment?" In fact the simplicity of this view is now generally acknowledged; and Albumen, Gluten, Casein, &c., are now recognized as flesh-formers in the same sense

that any animal aliment is. After alluding to the mineral ingredients, attention was directed to a diet-table, which contained some modifications, but was based on the one published in the *Agricultural Cyclopædia* under the article *Diet*: the table as shown being used in the calculation of the dietaries.

The old mode of estimating the value of dietaries, by merely giving the total number of ounces of solid food used daily or weekly, and quite irrespective of its composition, was shown to be quite erroneous; and an instance was given of an agricultural labourer in Gloucestershire, who in the year of the potato famine subsisted chiefly on flour, consuming 163 ounces weekly, which contained 26 ounces of flesh-formers. When potatoes cheapened he returned to a potato-diet and now eat 321 ounces weekly, although his true nutriment in flesh-formers was only about 8 or 10 ounces. He showed this further, by calling attention to the six pauper dietaries formerly recommended, to the difference between the salt and fresh meat dietary of the Sailor, &c., all of which, relying on absolute weight alone, had in reality no relation in equivalent nutritive value.

Attention was now directed to the diagrams exemplifying dietaries. Taking the Soldier and Sailor as illustrating healthy adult men, they consumed weekly about 35 ounces of flesh-formers, 70 to 74 ounces of carbon, the relation of the carbon in the flesh-formers to that of the heat-givers being 1 : 3. If the dietaries of the aged were contrasted with this, it would be found that they consumed less flesh-formers (25—30 ounces), but rather more heat-givers (72—78 ounces); the relation of the carbon in the former to that of the latter being about 1 : 5. The young boy, about ten or twelve years of age, consumed about 17 ounces weekly, or about half the flesh-formers of the adult man; the carbon being about 58 ounces weekly, and the relations of the two carbons being nearly 1 : 5½. The circumstances under which persons are placed influence these proportions considerably. In workhouses and prisons the warmth renders less necessary a large amount of food-fuel to the body; while the relative amount of labour determines the greater or less amount of flesh-formers. Accordingly it is observed that the latter are increased to the prisoners exposed to hard labour. From the quantity of flesh-formers in food, we may estimate approximatively the rate of change in the body. Now a man weighing 140lbs. has about 4lbs. of flesh in blood, 27½lbs. in his muscular substance, &c., and about 5lbs. of nitrogenous matter in the bones. These 37lbs. would be received in food in about eighteen weeks; or, in other words, that period might represent the time required for the change of the tissues, if all changed with equal rapidity, which is, however, not at all probable.

All the carbon taken as food is not burned in the body, part of of it being excreted with the waste matter. Supposing the respirations to be 18 per minute, a man expires about 8.59oz. of

carbon daily, the remainder of the carbon appearing in the excreted matter.

In conclusion, Dr. Playfair explained how the dietary-tables elucidated the various admixtures of food common to cookery, and how they might even be made to bear on certain national characteristics, which were in no small degree influenced by the aliments of different nations.

[L. P.

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## WEEKLY EVENING MEETING,

Friday, May 13.

THE DUKE OF NORTHUMBERLAND, K.G., F.R.S., President, in the Chair.

PROFESSOR EDWARD FORBES, F.R.S., President of the Geological Society.

### *On some New Points in British Geology.*

NOT many years ago it used to be said that the geology of England was done, and yet the best investigated localities are constantly affording fresh discoveries. When the Lecturer last year exhibited Captain Ibbetson's beautiful and accurate model of Whitecliff Bay in the Isle of Wight, in illustration of his views respecting the distribution of species in time, he had not the slightest suspicion that this particular locality, so often and apparently so thoroughly explored, could yield new results and new interpretations. Nevertheless, having had occasion, at the suggestion of Sir Henry De la Beche, to examine the tertiary strata of the Isle of Wight for the purposes of the Geological Survey of Great Britain, this very bay of Whitecliff proved to be a rich source of novel geological information. Moreover, a great portion of the Isle of Wight, on further examination, turned out to belong to a division of the older tertiaries, that had never been demonstrated to exist within the British Islands. As a general statement of these results and of their bearings may be more intelligible to non-professional lovers of geology than the detailed memoirs about to be published on the subject, Professor Forbes has taken this opportunity of communicating them to the Members of the Royal Institution.

The Isle of Wight is divided into two portions by a great chalk ridge running east and west. This is the ridge of vertical chalk beds. To the north of it, the country is composed of tertiary, to the

| | REMARKS. |
|---|---|
| **Dietari** | |
| **English Sol** | |
| **Do. in I** | Dietaries. |
| **English Sail** | |
| **Do.** | |
| **Dutch Soldi** | R. |
| **Do,** | |
| **French Sold** | Return obtained. |
| **Bavarian Do** | |
| **Hessian Do** | . |
| **Die** | |
| **Christ's Ho** | |
| **Do.** | Returns obtained. |
| **Chelsea Ho** | |
| **Greenwich H** | |
| **Di** | |
| **Greenwich F** | |
| **Chelsea** | Returns obtained. |
| **Gillespie Ho** | |
| **Trinity Hosp** | |
| **Old** | |
| Class 1. - | |
| „ 2. - | |
| „ 3. - | dietaries recommended as equivalent by the Poor-Law |
| „ 4. - | missioners. |
| „ 5. - | |
| „ 6. - | |
| *Average of* | y reduced from all the Unions in 1851. |
| St. Cuthbert | Returns. |
| City Workh | |
| **Engl** | |
| Class 2. | ed Prisoners exceeding 7 days, but not exceeding 21 days. |
| „ 3. | Do. Hard labour, exceeding 21 days but not than 6 weeks. |
| „ 4, 8 & | ed Prisoners, Hard labour, above 6 weeks and not more 4 months. |
| „ 5. | ed Prisoners, Hard labour, for terms exceeding 4 months. |
| **Ben** | |
| Non-Labou | |
| Working Co | |
| Contractors' | nformation supplied from the India House. |
| **Bom** | |
| All Classes o | |
| Hard Labou | |
| **Arcti** | |
| Esquimaux | probably repre- Extreme cases ioned by the wing authorities. { Ross, 1835, p. 448. Parry, 1823, p. 413. Cochrane, p. 255. Saritcheff. Barrow, pp. 152, 258. Richardson, *vide* Agric. Cyc. article *Diet*. |
| Yacut - | |
| Bosjesman | |
| Hottentot | |
| Agricultural | stershire } See Agric. Cyclopædia. |
| Do | hire |
| Do | r, Bombay — Return in Bombay Prison Dietaries. |

south, of older strata, as far down in the geological scale as the Wealden. The Lower Greensand or Neocomian beds occupy the greater part of the surface of the southern division, and freshwater tertiaries that of the northern. At Alum Bay, on the west, and Whitecliff Bay, on the east, the ends of the older tertiary strata, as they rise above the chalk, are seen truncated and upturned, being all affected by the movement which caused the verticality of the chalk. These tertiaries constitute the following groups, successively enumerated in ascending order, the Plastic clay, the Bognor series (equivalents of the true London clay), the Bracklesham series, and the Barton series, upon which lie the Headon Hill sands, and those freshwater strata that spreading out form the gently undulating country, extending from near the base of the chalk ridge to the sea.

Owing to the section at Headon Hill near Alum Bay being so clear and conspicuous, and their position being in the loftiest tertiary hill that exhibits its internal structure in the island, the fresh water and fluvio-marine beds which compose that elevation have long attracted attention and have been described by many observers, the first of whom was the late Professor Webster. The apparent slight inclination of these beds, as seen in the Headon section, except at the point where they are suddenly curved in conformity with the verticality of the chalk and the beds immediately above it, appear to have led geologists to the notion that the fluvio-marine portion of the Isle of Wight was composed entirely of continuations of the beds forming Headon Hill. Two observers only suspected a discrepancy, viz. Mr. Prestwich, who, in a short communication to the British Association at Southampton, expressed his belief that Hempstead Hill, near Yarmouth, would prove to be composed of strata higher than those of Headon; and the Marchioness of Hastings, who, having given much time to the search for the remains of fossil vertebrata in the tertiaries of the Isle of Wight and Hordwell, declared her conviction that these remains belonged to distinct species, according as they were collected at Hordwell, Hempstead, and Ryde, and that these three localities could not, as was usually understood, belong to the same set of strata. The recently published monograph of the pulmoniferous mollusks of the English Eocene Tertiaries, by Mr. Frederic Edwards, afforded also indications of the shells therein so well described and figured having been collected in strata of more than one age.

A few days' labour at the west end of the island convinced Professor Forbes that the surmises alluded to were likely to prove true, and that the structure of the north end of the island had been in the main misunderstood. After four months' constant work at both extremities and along the intermediate country, he succeeded in making out the true succession of beds, with most novel and gratifying results. During this work he was greatly aided by his colleague, Mr. Bristow, and by Mr. Gibbs, an indefatigable and able collector attached to the Geological Survey.

The freshwater strata of Whitecliff Bay proved to be wholly misinterpreted. Instead of their being constituted out of the Headon Hill strata only, more than a hundred feet thickness of them are additional beds characterized by peculiar fossils, and resting upon a marine stratum that overlies the Bembridge limestone, the equivalent of which at Headon is a soft concretionary calcareous marl, scarcely visible except in holes among the grass immediately under the gravel on the summit of the hill.

The beds of the true Headon series, in fact, are all included in the sub-vertical portion of the Whitecliff sections and are there present in their full thickness. They are succeeded by peculiar strata of intermediate character, for which the name of St. Helen's beds is proposed, and which become so important near Ryde that they constitute a valuable building stone. The Bembridge limestone that lies above is the same with the Binstead limestone near Ryde, out of which were procured the remains of quadrupeds of the genera Anoplotherium, Palæotherium, &c. identical with those found in the Gypsiferous beds of Montmartre. The Sconce limestone near Yarmouth is also the same, and none of these limestones are identical with any of those conspicuous among the fluvio-marine strata at Headon Hill, and with which they have hitherto been confounded. They are far above them, and are distinguished by distinct and peculiar fossils.

Almost all the country north of the chalk ridge, exclusive of the small strip occupied by the marine Eocenes, is composed of marls higher in the series than any of the Headon Hill beds, and hitherto wholly undistinguished, except in the Whitecliff section, where the age and relative position had been entirely mistaken. These are the Bembridge marls of Professor Forbes. Above them are still higher beds preserved only in two localities, viz. at Hempstead Hill, to the west of Yarmouth, and in the high ground at Parkhurst. For these the name of Hempstead series is proposed. Their characteristic fossils are very distinct, and the highest bed of the series is marine. These beds prove to be identical with the Limburg or Tongrien beds of Belgium and with the Gres de Fontainebleau series in France. We thus get a definite horizon for comparison with the continent, and are enabled to shew, that instead of our English series of Eocene tertiaries being incomplete in its upper stages as compared with those of France and Belgium, it is really the most complete section in Europe, probably in the world. We are enabled by it to correct the nomenclature used on the Continent, and to prove that the so called Lower Miocene formations of France and Germany are in true sequence with the Eocene strata, and are linked with them both stratagraphically and by their organic contents. We are also enabled to refer, with great probability, the so called Miocene tertiaries of the Mediterranean basin, of Spain and Portugal,—those of the well-known Maltese type—to their true position in the series, and to place them on a horizon with the Tongrien

division of the Eocenes. As these Maltese beds are unconformable, and evidently long subsequent to the deposition of the great nummuletic formation, we are enabled to assign an approximate limit to the estimate of the latest age of that important series. From well marked analogies we get at a probable date even for the Australian tertiaries. Thus the deciphering of the true structure of a small portion of the British Islands can throw fresh light upon the conformation of vast and far-apart regions.

The peculiar undulatory contour of the surface of the fluvio-marine portion of the Isle of Wight is due to the gentle rolling of these beds in two directions, one parallel with the strata of the chalk ridge, and the other at right angles to it. The valleys and hills running northwards to the sea depend upon the synclinal and anteclinal curves of the latter system of rolls, a fact hitherto unnoticed, and the non-recognition of which has probably been one cause of the erroneous interpretation of the structure of the Isle of Wight, hitherto received. The truncations of these curves along the coast of the Solent exhibit at intervals beautiful and much neglected sections, well worthy of careful study. There is one of these sections near Osborne. Her Majesty's residence stands upon a geological formation hitherto unrecognized in Britain. Near West Cowes there are several fine sections along the shore. The total thickness of unclassified strata in the Isle of Wight is four hundred feet, if not more, and within this range are at least two distinct sets of organic remains. The fluvio-marine beds in all, including the Headon series, are very nearly 600 feet thick.

[E. F.]

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## WEEKLY EVENING MEETING,

Friday, May 20.

SIR JOHN P. BOILEAU, Bart., F.R.S., Vice-President,
in the Chair.

DR. E. FRANKLAND, F.C.S.

*Observations, economical and sanatory, on the employment of Chemical Light for artificial Illumination.*

THERE are two principal sources of artificial light, viz. electricity and the chemical force; the latter, however, has been, and still is, the only practical source of all artificial light. Although light can be thus obtained by the chemical action of substances belonging to all three kingdoms, yet closer observation demonstrates that the

illuminating effect obtained from animal and mineral bodies is primarily derived from the vegetable kingdom; every plant being an apparatus for the absorption and concentration of light and heat from the solar rays, and for the retention of these forces during its passage through the subsequent stages in the formation of vegetable fuel.

Until the commencement of the present century artificial light was derived almost exclusively from the animal kingdom; but the great economy attending its immediate production from our vast stores of vegetable fuel is becoming more and more apparent, and is in fact so generally admitted, as to render more than a mere allusion to it and a glance at the following Table, unnecessary.

TABLE — shewing the comparative cost of light from various sources each equal to 20 sperm candles burning 120 grains per hour each, for 10 hours.

| | s. | d. |
|---|---|---|
| Wax - - - - | 7 | 2½ |
| Spermaceti - - - | 6 | 8 |
| Tallow - - - - | 2 | 8 |
| Sperm Oil (Carcel's Lamp) - | 1 | 10 |
| London Gases, B, C, D, E* - | 0 | 4¼ |
| Manchester Gas - - | 0 | 3 |
| London Gas, A. - - | 0 | 2¼ |

We will therefore confine our attention principally to the light produced from vegetable fuel, in considering the economical and sanatory bearings of artificial light.

The production of artificial light depends upon the fact, that at certain high temperatures all matter becomes luminous. The higher the temperature the greater is the intensity of the light emitted. The heat required to render matter luminous in its three states of aggregation differs greatly. Thus, solids are sometimes luminous at comparatively low temperatures, as phosphorus and phosphoric acids. (A jet of flame produced by the formation of these substances was exhibited, and its temperature shewn to be quite inadequate to the ignition or even scorching of the finest cambric or gun cotton.) Usually, however, solids require a temperature of 600° or 700° F. to render them luminous in the dark, and must be heated to 1000° F. before their luminosity becomes visible in daylight. Liquids require about the same temperature. But to render gases luminous, they must be exposed to an immensely higher temperature; even the intense heat generated by the oxy-hydrogen blowpipe scarcely suffices to render the aqueous vapour produced visibly luminous, although

* London Gases, A, B, C, D, E.—These are the gases furnished to consumers by five of the principal London Companies. For obvious reasons the names of the Companies are not mentioned.

solids, such as lime, emit light of the most dazzling splendour when they are heated in this flame. Hence, those gases and vapours only can illuminate, which produce or deposit solid or liquid matter during their combustion. This dependence of light upon the production of solid matter is strikingly seen in the case of phosphorus, which when burnt in chlorine produces a light scarcely visible; but, when consumed in air or oxygen, emits light of intense brilliancy: in the former case the *vapour* of chloride of phosphorus is produced, in the latter *solid* phosphoric acid.

Several gases and vapours possess this property of depositing solid matter during combustion, but a few of the combinations of carbon and hydrogen are the only ones capable of practical application: these latter compounds evolve during combustion only the same products as those generated in the respiratory process of animals, viz. carbonic acid and water. The solid particles of carbon which they deposit in the interior of the flame, and which are the source of light, are entirely consumed on arriving at its outer boundary; their use as sources of artificial light under proper regulations is therefore quite compatible with the most stringent sanatory rules.

In the usual process of gas manufacture there are generated in addition to these illuminating hydrocarbons two other classes of gaseous constituents, viz. impurities and diluents. With the exception of bisulphuret of carbon and some organic compounds containing sulphur, all the impurities are removed in the usual processes of purification, which have now been brought to great perfection; but the presence of these sulphur compounds in coal gas is very objectionable, and constitutes the chief barrier to the universal employment of gas in dwelling-houses. The attention of the manufacturer ought therefore now to be earnestly directed to the discovery of means for preventing the formation of these compounds, as it will probably be found impossible to remove them from the gas when once they have been formed.

In addition to traces of these sulphur compounds, purified coal gas contains only the following ingredients.

| | | Formula. |
|---|---|---|
| Illuminating constituents. | Olefiant Gas - - - | $C_2\ H_2$ |
| | Propylene ? - - - | $C_3\ H_3$ |
| | Butylene ? - - - | $C_4\ H_4$ |
| | Other Hydrocarbons - - | unknown |
| Diluents. | Light carburetted hydrogen - | $C\ H_2$* |
| | Hydrogen - - - | $H$ |
| | Carbonic Oxide - - | $C\ O$ |

* This gas has usually been described as possessing a certain amount of

The light emitted during the combustion of coal gas is due entirely to the first or illuminating class of constituents, which yield an amount of light proportional to the quantity of carbon contained in a given volume; thus, propylene and butylene yield respectively 50 and 100 per cent more light than olefiant gas, because they contain respectively 50 and 100 per cent more carbon in a given volume.

It would not be desirable to employ a gas containing only luminiferous ingredients, even if it were possible to manufacture such a gas, because it is exceedingly difficult to consume these constituents without the production of smoke attendant on imperfect combustion. A diluting material is therefore necessary to give the flame a sufficient volume, so as to separate the particles of carbon farther asunder, and thus diminish the risk of their imperfect combustion.

All the three diluents above-mentioned perform this office equally well; but if we study their behaviour during combustion we shall find that in a sanatory point of view hydrogen is greatly to be preferred.

The two objections most frequently urged against the use of gas in apartments are, first, the heat which it communicates to the atmosphere, and, second, the deterioration of the air by the production of carbonic acid. Now, in their action upon the atmosphere in which they are consumed, the above three diluents present striking differences in these two respects.

One cubic foot of light carburetted hydrogen, at 60° F. and 30 in. barometrical pressure consumes two cubic feet of oxygen during its combustion, and generates one cubic foot of carbonic acid, yielding a quantity of heat capable of heating 5 lbs. 14 oz. of water from 32° to 212°, or causing a rise of temperature from 60° to 80.8° in a room containing 2,500 cubic feet of air.

One cubic foot of carbonic oxide at the same temperature and pressure consumes during combustion $\frac{1}{2}$ a cubic foot of oxygen, generates one cubic foot of carbonic acid, and affords heat capable of raising the temperature of 1 lb. 14 oz. of water from 60° to 66.6°.

One cubic foot of hydrogen, at the same temperature and pressure, consumes $\frac{1}{2}$ cubic foot of oxygen, generates no carbonic acid, and yields heat capable of raising the temperature of 1 lb. 13 oz. of water from 32° to 212° or that of 2,500 cubic feet of air from 60 to 66.4°.

This comparison shews the great advantage which hydrogen possesses over the other diluents, especially over light carburetted hydrogen, which is evidently a very objectionable constituent, and

illuminating power, but a specimen of it brought from the coal strata beneath Chat Moss, Lancashire, shewed that it yields no more light than hydrogen or carbonic oxide when consumed from a *fish-tail* burner.

shews that a normal gas for illuminating purposes should consist of illuminating hydrocarbons diluted with pure hydrogen. No method is known by which a gas of exactly this composition can be manufactured, but a very close approximation has been lately made to this normal gas, by the employment of a process known as White's Hydrocarbon method of gas-making. In this process the very ingenious principle is adopted of generating the illuminating constituents in as concentrated a form as possible in one retort, and the diluents consisting principally of hydrogen free from light-carburetted hydrogen in another. By this arrangement the diluents can be employed for a very remarkable and highly interesting purpose; they are conducted through the retort in which the illuminating constituents are being generated, in such a manner as rapidly to sweep out those constituents, before they have time to become decomposed by contact with the red hot interior surfaces of the retort, a mode of destruction which occurs so largely in the usual process of gas-making. This mode of treatment produces a gain in the amount of illuminating power derived from a given weight of coal, equal to from 50 to upwards of 100 per cent, whilst the increase in quantity of gas is frequently 300 per cent.

The gas thus manufactured differs principally from coal gas made by the ordinary process, in having a large portion of the light carburetted hydrogen replaced by hydrogen; it is therefore in a sanatory point of view the best gas hitherto produced. This is seen in the following Table, which exhibits the amount of carbonic acid and heat generated per hour by various sources of light, each equal to 20 sperm candles burning at the rate of 120 grains of sperm per hour.

| | Carbonic Acid. | Heat. |
|---|---|---|
| Tallow - - | 10.1 cubic feet | 100 |
| Wax - - } Spermaceti - - } | 8.3 " " | 82 |
| Sperm Oil (Carcel's Lamp) | 6.4 " " | 63 |
| London Gases, B, C, D, E, | 5.0 " " | 47 |
| Manchester Gas - | 4.0 " " | 32 |
| London Gas, A. - | 3.0 " " | 22 |
| Boghead Hydrocarbon Gas | 2.6 " " | 19 |
| Lesmahago Hydrocarbon Gas | 2.5 " " | 19 |

Notwithstanding the great economy and convenience attending the use of gas, and, in a sanatory point of view, the high position which, as an illuminating agent, coal gas of proper composition occupies, its use in dwelling houses is still extensively objected to. The objections are partly well founded and partly groundless. As is evident from the foregoing table, even the worst London gases produce, for a given amount of light, less carbonic acid and heat than either lamps or candles. But then, where gas is used, the consumer is never satisfied with a light equal in brilliancy only to

that of lamps or candles, and consequently, when three or four times the amount of light is produced from a gas of bad composition, the heat and atmospheric deterioration, greatly exceed the corresponding effects produced by the other means of illumination. By using a gas however of nearly the normal composition, such as the hydrocarbon gases above named, it is evident that three or four times the light may be employed, with the production of no greater heat or atmospheric deterioration, than that caused by wax candles or the best constructed oil lamps.

But there is nevertheless a real objection to the employment of gas-light in apartments, founded upon the production of sulphurous acid during its combustion: this sulphurous acid is derived from bisulphuret of carbon, and the organic sulphur compounds, which have already been referred to as incapable of removal from the gas by the present methods of purification.

The formation of sulphurous acid can readily be proved and even its amount estimated, by passing the products of combustion of a jet of gas through a small Liebig's condenser; the condensed product being heated to boiling with the addition of a few drops of nitric acid, and then treated with solution of chloride of barium, yields a white precipitate of sulphate of barytes, if any sulphur compound be present in the gas.

These impurities, which are encountered in almost all coal gas now used, are the principal if not the only source of the unpleasant symptoms experienced by many sensitive persons, in rooms lighted with gas. It is also owing to the sulphurous acid generated during the combustion of these impurities, that the use of gas is found to injure the bindings of books, and impair or destroy the delicate colours of tapestry. Therefore the production of gas free from these noxious sulphur compounds is at the present moment a problem of the highest importance to the gas manufacturer, and one which demands his earnest attention.

As it is nearly impossible for the consumer to procure gas free from these objectionable compounds, the only method of obviating their unpleasant and noxious effects is to remove entirely the products of combustion from the apartments in which the gas is consumed, and thus prevent them from mingling with the circumambient air. This suggestion was first made by Faraday, who, for accomplishing this object, contrived the very beautiful and effective ventilating burner exhibited in operation upon the lecture table. This apparatus, which is used at Buckingham Palace, Windsor Castle, the House of Peers, and in many public buildings, may be truly said to have brought gas illumination to perfection; for not only are all the products of combustion conveyed at once into the open air, but nearly the whole of the heat is in like manner prevented from communicating itself to the atmosphere of the room. The only obstacles to the universal adoption of this description of burner are its expense, and the difficulty of conveying the ventilating tube safely into the nearest

flue without injuring the architectural appearance of the room. The public at large will therefore still await the removal of the objectionable compounds in question, by the gas manufacturer, before they will universally adopt this otherwise delightful means of artificial illumination.

There are yet several other points of an economical and sanatory nature connected with the use of artificial light, but time does not permit of their discussion.

In conclusion, whilst coal gas is indisputably the most economical means of illumination, different varieties of that gas possess exceedingly variable values which ought to be known by the consumer.

The high sanatory position which gas takes, with regard to the production of a minimum amount of carbonic acid and heat, for a given amount of light, ought to stimulate the manufacturer to perfect the process, by removing all sulphur compounds, and attaining the most desirable composition, so that this economical, and, if pure, agreeable and sanatory light, may contribute to our domestic comfort to a much greater extent than it has hitherto done.

[E. F.]

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## WEEKLY EVENING MEETING,

Friday, May 27.

Right Hon. Baron Parke, Vice-President, in the Chair.

B. C. Brodie, Esq., F.R.S.

*On the formation of Hydrogen and its Homologues.*

In, what is termed, mineral chemistry, chemical substances are classified according to the different nature of the elements of which they consist. But in organic chemistry this distinction is no longer available. Organic substances were formerly defined as triple compounds of carbon, hydrogen, and oxygen, and this, with the statement of the relative proportion of these elements in any given compound, was all that was attempted to be made out as to its constitution. But this class of bodies is more numerous, possibly, than all the other chemical substances taken together, with which we are acquainted, and some further distinction was necessary for the purposes of science. The sagacity of certain chemists at length discovered a relation which was capable of becoming the basis of a truly rational and natural classification. It was perceived that in the long series of chemical changes of which these bodies were susceptible, the whole of the substance did not change, and that,

in these combinations, certain *groups* of elements had the same persistent character and fulfilled the same chemical function as the simple elements themselves in other* bodies. These constant groups have been named *radicals*. Among these those hydrocarbons termed the homologues of hydrogen are of special interest. Ethyl, a groupe consisting of two atoms of carbon and five of hydrogen, $C_2 H_5$, is one of these bodies. Assuming water as two atoms of hydrogen and one of oxygen, H H O, alcohol is composed of one atom of ethyl, one of hydrogen, and one atom of oxygen, $(C_2 H_5)$ H O. Hydriodic acid, the iodide of hydrogen, consists of an atom of hydrogen combined with an atom of iodine, H I. The iodide of ethyl consists of an atom of ethyl combined with an atom of iodine, $(C_2 H_5)$ I. It is from these and other like analogies between hydrogen and ethyl, that the idea arose of the similarity in their chemical function.

Certain chemists however conceived these views to be mere fanciful speculations. Their principal objection, reasonable or not, was that this ethyl was a purely ideal substance. From hydrochloric acid, or from water, we readily procure hydrogen. We separate metals from their combinations; but ethyl could not thus be obtained, and there was a point where it seemed that this analogy failed. Frankland however has silenced this objection in the most satisfactory manner, namely by procuring and isolating this ethyl.

He prepared it by a modification of the form of experiment by which hydrogen itself is prepared. He placed together zinc and iodide of ethyl in tubes hermetically sealed, and heated them considerably above the boiling point of water. On opening the tubes the ethyl escapes as a colourless combustible gas. There is only one property of ethyl on which I need dwell, its weight—it is about twice the weight of air.

Ethyl, however, when procured, did not realize all the anticipations formed of it, and there was one very important difference between the actual and the anticipated ethyl. It was supposed that when zinc acts upon iodide of hydrogen it takes away (so to say) the iodine, and the hydrogen becomes, what is termed, *free*, and the same with ethyl. On this view ethyl would have a certain atomic constitution, $C_2 H_5$. Now there is much reason to believe, that in the gaseous form the molecules of all bodies occupy the same space, whether this molecule consist of two only, or, as may be the case, of one hundred atoms. Hence to ascertain of how many atoms the molecule of a substance consists, we have simply to compare its weight in the gaseous form, with that of some other gas of which the molecule is already determined. When this experiment was made with ethyl, it was found to be just twice as heavy as it should be; that is to say, the space which should have contained two atoms of carbon and five of hydrogen, was found to contain just twice that quantity, or $C_4 H_{10}$.

Some chemists considered that ethyl was an exception to the

general rule, and that the molecule of ethyl only occupied half the space of the molecule of other bodies, so that the same space which contained one molecule of water truly contained two molecules of ethyl. This however is evidently but an arbitrary assumption to meet the case. Others said that, after all, the true ethyl remained yet to be discovered, and that this body was not it, but a hydrocarbon isomeric with it, for that the real ethyl would have only half the density of this body.

There is, however, a third view, on which the ethyl of theory is also the ethyl of fact. On a former occasion I shewed reasons for believing that the elements are in a certain sense compound molecular groupes, consisting of two or more atoms, which (in the present state of our knowledge) we must regard as similar, united to form a compound molecule. On this idea the gas hydrogen is represented, not by the symbol H, but as H H : and ethyl the analogue of hydrogen would also consist of a double atom, and be represented not as $C_2\ H_5$, but as $C_2\ H_5\ C_2\ H_5$.

The old view, however, had always a certain advantage over this, in the clear and consistent account which it gave of the mode of formation of hydrogen. How is it, it may be asked, and by what process, that this compound atom of hydrogen is formed? The answer is by no means obvious. Indeed the investigation of the nature of the process by which ethyl was formed, alone gave the key to its solution.

Ethyl is not, in truth, made by the direct action of zinc upon the iodide of ethyl; but by the intervention of another body, which belongs to the class of, what I may term, fugitive or evanescent combinations, and which is made and decomposed again in the course of the experiment. This body is zinc-ethyl. The molecule of zinc, consisting of two atoms Zn Zn, splits into two parts. One atom, Zn, combines with the iodine of the iodide of ethyl, $C_2\ H_5\ I$, to form iodide of zinc, Zn I, while the other atom at the same moment combines with the ethyl, forming zinc-ethyl, Zn $C_2\ H_5$.

The mode of action of zinc-ethyl upon iodide of ethyl is perfectly analogous to its action upon water. In contact with water, H H O, it immediately decomposes, forming hydrated oxide of zinc, Zn H O, and hydride of ethyl $C_2\ H_5$ H. This hydride of ethyl has hardly more than half the density of the ethyl gas. In the same space in which, in the other case, are contained two heavy atoms of ethyl are here contained one heavy atom of ethyl and one light atom of hydrogen. Now the zinc-ethyl with the iodide of ethyl decomposes in a perfectly similar manner, forming iodide of zinc, Zn I, and ethyl gas $C_2H_5\ C_2H_5$. That this is truly the mode of the formation of the ethyl is proved by the fact, that by careful modification of the experiment, it is possible to break up this process of the formation of the ethyl into the two factors (so to say) of which it consists.* At a low temperature the

* See Quarterly Journal of the Chemical Society, Vol. III. p. 405.

zinc-ethyl alone isformed. At a higher temperature the zinc-ethyl disappears and the ethyl is produced.

It is evident that the formation of the compound molecule of hydrogen H H, must be a very different physical event to the formation of the single atom of hydrogen H, if such could exist. The ordinary hypothesis of the '*liberation*' of hydrogen gives us no conception of its nature: we need some other explanation.

It seems to me probable that when zinc acts on hydrochloric acid and water, there are, as in the case of ethyl, two steps in the process; the first, the formation of a zinc-hydrogen, Zn H, the second, the action of this zinc-hydrogen on the water with the formation of hydrated oxide of zinc, Zn H O, and hydrogen gas H H. There are various arguments in favour of this view. First, it explains the result, which the other hypothesis does not. Secondly, the analogy of ethyl compels us to it. It is not probable that bodies so similar, in other respects, are dissimilar in the mode of their formation. Thirdly, there is, at least, one experiment in which we are absolutely able to analyse the process of the formation of hydrogen and to prove that it does take place in this manner.

This remarkable experiment is the formation of hydrogen by the decomposition of hypophosphorous acid by copper salts.* Hypophosphorous acid is, like zinc, what is termed a reducing agent. It precipitates certain metals from their solutions, and by a process of disoxydation decomposes alkalies with the formation of phosphorous acid and hydrogen. If this hypophosphorous acid be *boiled* with the copper salt, nothing is perceived but the formation of metallic copper and hydrogen gas; but if the solution be gradually heated, and the action arrested at a certain point, it can be shewn that this formation of hydrogen is preceded by the formation of a combination of hydrogen and copper, $Cu_2H$, analogous to zinc-ethyl. The part which this bears in the formation of the hydrogen is distinctly shewn by the action of acids, hydrochloric acid, H Cl, for example, upon it. This acid, which does not act upon metallic copper, immediately decomposes this body, forming protochloride of copper, $Cu_2Cl$, and hydrogen HH.

This hydride of copper has only a very ephemeral existence. It is decomposed very nearly at the same temperature at which it is produced, and its formation, for this reason, had long been overlooked by chemists. We can hence readily comprehend that other combinations of this class may take place in the case of which the temperature of formation and of decomposition may either coincide, or so closely approximate to each other, that it may ever be impossible to isolate the substance produced. This is probably the case in the action of zinc.

[B. C. B.]

* See Annales de Chimie, III. Serie, tome XI. p. 250.

## WEEKLY EVENING MEETING,

Friday, June 3.

THE DUKE OF NORTHUMBERLAND, K.G., F.R.S., President, in the Chair.

DR. JOHN TYNDALL, F.R.S.

*On some of the Eruptive Phœnomena of Iceland.*

THE surface of Iceland slopes gradually from the coast towards the centre, where the general level is about 2000 feet above the surface of the sea. On this, as a pedestal, are planted the Jökull or icy mountains of the region, which extend both ways in a north-easterly direction. Along this chain the active volcanoes of the island are encountered, and in the same general direction the thermal springs occur, thus suggesting a common origin for them and the volcanoes. From the ridges and chasms which diverge from the mountains mighty masses of steam are observed to issue at intervals, hissing and roaring, and where the escape takes place at the mouth of a cavern and the resonance of the cave lends its aid, the sound is like that of thunder. Lower down in the more porous strata we have smoking mud pools, where a repulsive blue-black aluminous paste is boiled, rising at times into huge bladders, which on bursting scatter their slimy spray to a height of fifteen or twenty feet. From the base of the hills upwards extend the glaciers, and on their shoulders are placed the immense snow-fields which crown the summits. From the arches and fissures of the glaciers, vast masses of water issue, falling at times in cascades over walls of ice, and spreading for miles and miles over the country before they find definite outlet. Extensive morasses are thus formed, which lend their comfortless monotony to the dismal scene already before the traveller's eye. Intercepted by the cracks and fissures of the land, a portion of these waters is conducted to the hot rocks underneath; here meeting with the volcanic gases which traverse these underground regions, both travel together, to issue at the first convenient opportunity either as an eruption of steam or as a boiling spring.

The origin of the water which feeds the springs is here hinted at. That origin is atmospheric. The summits of the Jökull arrest and mix the clouds, and thus cause an extraordinary deposition of snow and rain. This snow and rain constitute the source from which the springs are fed. The nitrogen and ammonia which occur, without exception, in every spring, exactly as we find them in rain water, furnish the proof of this; for the known deportment of these

substances preclude them from being regarded as real volcanic products.

The springs of Iceland permit of being divided into two great classes; one class turns litmus paper red, the other restores the colour; one class is acid, the other alkaline. Periodical eruptions are scarcely ever known to occur among the former, while to the latter belong the Geisers of the island. Here then we have two facts which form the termini of a certain chain of operations — the water of the clouds and the water of the spring: in its passage from one terminus to the other is to be sought the cause of those changes which the water has undergone.

In seeking insight here, experiment is our only safe guide. Let us endeavour to combine the agencies of nature, and see whether we cannot produce her results. Sulphurous acid is one of the most important gases which the water encounters in its passage. Now if a piece of palagonite, the rock through which the water filters, be heated with an excess of aqueous sulphurous acid, it dissolves in the cold to a fluid coloured yellow brown by the presence of peroxide of iron. On heating the fluid this peroxide is converted into protoxide; a portion of its oxygen goes to the sulphurous acid, forming sulphuric acid, which combines with the bases of the rock and holds them in solution. This is the first stage of the fumarole process. But if the process ended here, we might expect to find the dissolved constituents of the rock in the resultant spring, which is by no means the case, as a glance at the following table will shew.

Relation of Bases.

| | In Palagonite. | In the Suffion water. |
|---|---|---|
| Oxide of iron | 36.75 | 0.00 |
| Alumina | 25.50 | 12.27 |
| Lime | 20.25 | 42.82 |
| Magnesia | 11.39 | 29.42 |
| Soda | 3.44 | 9.51 |
| Potash | 2.67 | 5.98 |
| | 100.00 | 100.00 |

We see here that the rock contains a large quantity of the oxide of iron, while the spring does not contain a trace of it. It is, however, an experimental fact that the oxide of iron has been dissolved with the rest. How is its disappearance to be accounted for? The very rock from which it was originally extracted possesses the power of re-precipitating it, when by further contact with the rock the solution which contains it has its excess of acid absorbed and has thus become neutral. In this way the aqueous sulphurous acid acts as a carrier to the iron, taking up its burden here and laying it down there; and this process of transference can be clearly traced

in the rocks themselves. Where the iron has been extracted, the rock has become a mass of white clay, where the iron is re-deposited the mass exhibits the colour produced by iron. But it would weary the audience, and thus defeat the object of the lecture, were the details thus minutely dwelt upon. Let it suffice therefore to weld swiftly together the links of the great chain operations, to which the various thermal springs and gaseous eruptions of Iceland owe their existence and peculiarities.

Hydrochloric acid, though playing a far less important part in Iceland than at Vesuvius and Etna, is nevertheless present. The presence of common salt is proved by the fact of its being found as one of the products of sublimation. Now it is a well known fact that this substance, exposed to a high heat in the presence of silica and the vapour of water, is decomposed; the sodium takes the oxygen of the water and becomes soda, the chlorine takes the hydrogen and forms hydrochloric acid. There is no difficulty, therefore, in accounting for the origin of this gas, as all the conditions for its formation are present.

Sulphurous acid and sulphuretted hydrogen play a most important part in Iceland; — how can their presence be accounted for? Let a piece of one of the igneous rocks of the island be heated to redness, and permit the vapour of sulphur to pass over it. The oxide of iron of the rock is decomposed; a portion of the sulphur unites with the iron, which remains as sulphuret; the liberated oxygen unites with the remaining sulphur, and forms sulphurous acid. Let the temperature of the heated mass sink till it descends just below a red heat, and then let the vapour of water be passed over it; a decomposition of the sulphuret before formed is the consequence; the iron is reoxidised, and the liberated sulphur unites with the free hydrogen to form sulphuretted hydrogen, and thus the presence of two of the most important agents in these phenomena is accounted for. These are experimental facts capable of being repeated in the laboratory, and the chronological order of the gases thus produced is exactly the same as that observed in nature. In the active volcanoes, where the temperature is high, we have the sulphurous acid; in the dormant ones, where the temperature has sunk so far as to permit of the decompositions just described, we have the sulphuretted hydrogen. This accounts for the irregular and simultaneous appearance of these two gases in various parts of the island. At Krisuvik, for example, exhalations of sulphurous acid, sulphuretted hydrogen, steam, and sulphur, * burst in wild disorder from the hot ground. The first two gases cannot exist amicably together. In Iceland they wage incessant war, mutually decompose each other, and scatter their sulphur over the steaming fields. In this way the true salfataras of the island are formed.

* In nature the vapour of sulphur is doubtless derived from the action of heat upon certain sulphur compounds.

In process of time, however, the heat retires to greater depths, the sources of the sulphurous acid and sulphuretted hydrogen become by degrees exhausted, and at such places the acid reaction of the soil disappears. Carbonic acid is found in abundance everywhere, but as long as the more powerful sulphuric acid is present the former must remain free. But when the acid reaction has disappeared, the carbonic acid combines with the alkaline bases, the bicarbonates thus formed impregnate the thermal waters, and become solvents for the silica which these waters are known to contain in such surprising abundance, and which, as we shall presently see, furnishes the materials for the wonderful architecture of the Geisers.

Casting our thoughts back upon the foregoing description, the hypothesis of internal heat will be seen to be implied, and from this as a *cause* we have deduced the various chemical phenomena as *consequences*. Holding fast by experiment, we see that the various gases whose existence has been urged as one of the strongest proofs of the so called chemical theory, follow in the most natural and necessary manner from the rival supposition. Given the heat and the materials the results are such as any chemist acquainted with the reactions might predict *à priori*. By the labours of a chemist indeed a new and wonderful light has been thrown upon the entire volcanic phenomena of Iceland. With implicit reliance on the applicability of his science to the solution of these phenomena, he has travelled side by side with nature, combined her conditions, and produced her effects. Basing all his reasoning upon experiment, he has given to his conclusions a stability which mere speculation, however plausible, could never claim. That chemist is Bunsen, to whose researches in Iceland the audience were indebted for the materials of the present discourse.

The Lecturer then adverted to the Geisers; and proposed, as his time was limited, to confine his attention to the Great Geiser. We have here a tube ten feet wide and seventy feet deep; it expands at its summit into a basin, which from north to south measures fifty-two feet across, and in the perpendicular direction sixty feet. The interior of the tube and basin is coated with a beautiful smooth plaster, so hard as to resist the blows of a hammer. The first question that presents itself is, how was this wonderful tube constructed? How was this perfect plaster laid on? A glance at the constitution of the Geiser water will perhaps furnish the first surmise. In 1000 parts of the water the following constituents are found: —

| | |
|---|---|
| Silica | 0.5097 |
| Carbonate of Soda | 0.1939 |
| Carbonate of Ammonia | 0.0083 |
| Sulphate of Soda | 0.1070 |
| Sulphate of Potash | 0.0475 |
| Sulphate of Magnesia | 0.0042 |
| Chloride of Sodium | 0.2521 |

| | |
|---|---|
| Sulphide of Sodium . . . . | 0.0088 |
| Carbonic Acid . . . . | 0.0557 |

The lining of the tube is silica, evidently derived from the water; and hence the conjecture may arise that the water deposited the substance against the sides of the tube and basin. But the water deposits no sediment, even when cooled down to the freezing point. It may be bottled up and kept for years as clear as crystal, and without the slightest precipitate. A specimen brought from Iceland and analyzed in this Institution was found perfectly free from sediment. Further, an attempt to answer the question in this way would imply that we took it for granted that the shaft was made by some foreign agency and that the spring merely lined it. A painting of the Geiser, the property of Sir Henry Holland — himself an eye-witness of these wonderful phenomena,—was exhibited. The painting, from a sketch taken on the spot, might be relied on. We find here that the basin rests upon the summit of a mound; this mound is about forty feet in height, and a glance at it is sufficient to shew that it has been deposited by the Geiser. But in building the mound, the spring must also have formed the tube which perforates the mound; and thus we learn that the Geiser is the architect of its own tube. If we place a quantity of the Geiser water in an evaporating basin, the following takes place: in the centre the fluid deposits nothing, but at the edges where it is drawn up the sides of the basin by capillary attraction, and thus subjected to a quick evaporation, we find silica deposited; round the edge we find a ring of silica thus laid on, and not until the evaporation is continued for a considerable time, do we find the slightest turbidity in the central portions of the water. This experiment is the microscopic representant, if the term be permitted, of nature's operations in Iceland. Imagine the case of a simple thermal spring whose waters trickle over its side down a gentle incline; the water thus exposed evaporates speedily, and silica is deposited. This deposit gradually elevates the side over which the water passes until finally the latter has to choose another course; the same takes place here, the ground becomes elevated by the deposit as before, and the spring has to go forward—thus it is compelled to travel round and round, discharging its silica and deepening the shaft in which it dwells, until finally, in the course of centuries, the simple spring has produced that wonderful apparatus which has so long puzzled and astonished both the traveller and the philosopher.

Before an eruption, the water fills both the tube and basin, detonations are heard at intervals, and after the detonation a violent ebullition in the basin is observed; the column of water in the pipe appears to be lifted up, thus forming a conical eminence in the centre of the basin and causing the water to flow over its rim. The detonations are evidently due to the production of steam in the subterranean depths, which rising into the cooler water of the tube,

becomes condensed and produces explosions similar to those produced on a small scale when a flask of water is heated to boiling. Between the interval of two eruptions, the temperature of the water in the tube towards the centre and bottom gradually increases. Bunsen succeeded in determining its temperature a few minutes before a great eruption took place; and these observations furnished to his clear intellect the key of the entire enigma. A little below the centre the water was within two degrees of its boiling point, that is within two degrees of the point at which water boils under a pressure equal to that of an atmosphere, *plus the pressure of the superincumbent column of water*. The actual temperature at thirty feet above the bottom was 122° centigrade, its boiling point here is 124°. We have just alluded to the detonations and the lifting of the Geiser column by the entrance of steam from beneath. These detonations and the accompanying elevation of the column are, as before stated, heard and observed at various intervals before an eruption. During these intervals the temperature of the water is gradually rising; let us see what *must* take place when its temperature is near the boiling point. Imagine the section of water at 30 feet above the bottom to be raised six feet by the generation of a mass of vapour below. The liquid spreads out in the basin, overflows its rim, and thus the elevated section has six feet less of water pressure upon it; its boiling point under this diminished pressure is 121°; hence in its new position, its actual temperature (122°) is a degree above the boiling point. This excess is at once applied to the generation of steam; the column is lifted higher, and its pressure further lessened; more steam is developed underneath; and thus, after a few convulsive efforts, the water is ejected with immense velocity, and we have the Geiser eruption in all its grandeur. By its contact with the atmosphere the water is cooled, falls back into the basin, sinks into the tube through which it gradually rises again, and finally fills the basin. The detonations are heard at intervals, and ebullitions observed; but not until the temperature of the water in the tube has once more nearly attained its boiling point is the lifting of the column able to produce an eruption.

In the regularly formed tube the water nowhere quite attains the boiling point. In the canals which feed the tube, the steam which causes the detonation and lifting of the column must therefore be formed. These canals are in fact nothing more than the irregular continuation of the tube itself. The tube is therefore the sole and sufficient cause of the eruptions. Its sufficiency was experimentally shewn during the lecture. A tube of galvanized iron six feet long was surmounted by a basin; a fire was placed underneath and one near its centre to imitate the lateral heating of the Geiser tube. At intervals of five or six minutes, throughout the lecture, eruptions took place; the water was discharged into the atmosphere, fell back into the basin, filled the tube, became heated again, and was discharged as before.

Sir Geo. Mackenzie it is well known was the first to introduce the idea of a subterranean cavern to account for the phenomena of the Geiser. His hypothesis met with general acceptance, and was even adopted undoubtingly by some of those who accompanied Bunsen to Iceland. It is unnecessary to introduce the solid objections, which might be urged against this hypothesis, for the tube being proved sufficient, the hypothetical cavern disappears with the necessity which gave it birth.

From the central portions of the Geiser tube downwards, the water has stored up an amount of heat capable, when liberated, of exerting an immense mechanical force. By an easy calculation it might be shewn that the heat thus stored up could generate, under ordinary atmospheric pressure, a column of steam having a section equal to that of the tube and a height of nearly *thirteen hundred yards*. This enormous force is brought into action by the lifting of the column and the lessening of the pressure described above.

A moment's reflection will suggest to us that there must be a limit to the operations of the Geiser. — When the tube has reached such an altitude that the water in the depths below, owing to the increased pressure, cannot attain its boiling point, the eruptions of necessity cease. The spring however continues to deposit its silica and forms a *laug* or cistern. Some of these in Iceland are of a depth of thirty or forty feet. Their beauty is indescribable; over the surface a light vapour curls, in the depths the water is of the purest azure, and tints with its own hue the fantastic incrustations on the cistern walls; while at the bottom is observed the mouth of the once mighty Geiser. There are in Iceland traces of vast, but now extinct, Geiser operations. Mounds are observed whose shafts are filled with rubbish, the water having forced a way underneath and retired to other scenes of action. We have in fact the Geiser in its youth, manhood, old age, and death, here presented to us: — in its youth as a simple thermal spring, in its manhood as the eruptive spring, in its old age as the tranquil *laug*, while its death is recorded by the ruined shaft and mound which testify the fact of its once active existence.

Next to the Great Geiser the Strokkur is the most famous eruptive spring of Iceland. The depth of its tube is forty-four feet. It is not, however, cylindrical like that of the Geiser, but funnel-shaped. At the mouth it is eight feet in diameter, but it diminishes gradually, until near the centre the diameter is only ten inches. By casting stones and peat into the tube and thus stopping it, eruptions can be forced which in point of height often exceed those of the Great Geiser. Its action was illustrated experimentally in the lecture, by stopping the galvanized iron tube before alluded to loosely with a cork. After some time the cork was forced up and the pent-up heat converting itself suddenly into steam, the water was ejected to a considerable height; thus demonstrating that in this case the tube alone is the sufficient cause of the phenomenon.

[J. T.]

## GENERAL MONTHLY MEETING,

### Monday, June 6.

William Pole, Esq., M.A., F.R.S., Treasurer and Vice-President, in the Chair.

Alex. Wm. Grant, Esq.
Benjamin Gray, Esq.
Leo Schuster, Esq.

were duly *elected* Members of the Royal Institution.

John R. F. Burnett, Esq.

was duly *admitted* a Member of the Royal Institution.

The following Presents were announced, and the thanks of the Members ordered to be returned for the same:—

From

*Astronomical Society, Royal*—Monthly Notices, Vol. XIII. No. 6. 8vo. 1853.
*Asiatic Society of Bengal*—Journal, No. 231. 8vo. 1852.
*Beer, Dr. August (the Author)*—Einleitung in die höhere Optik. Braunschweig, 1853.
*Bristol Blind Asylum Committee*—Memoir of James Watt, printed for the Use of the Blind. Obl. 8vo. 1853.
*British Architects, Royal Institute of*—Proceedings for May, 1853. 4to.
*Civil Engineers, Institution of*—Proceedings for May, 1853. 8vo.
*Earl, G. W. Esq.*—Correspondence relating to the Discovery of Gold in Australia. 8vo. 1853.
*Editor*—The Medical Circular for May, 1853. 4to.
*Faraday, Mr. James,*—Faraday on the Ventilation of Lamp-burners. 8vo. 1843.
*Faraday, Professor, F.R.S. &c. &c.*—Abhandlungen der Akademie der Wissenschaften zu Berlin, aus dem Jahre 1851. 4to. Berlin, 1852.
Kaiserliche Akademie der Wissenschaften, Wien:—
Almanach: 3te Jahrgang. 16mo. 1853.
Der feierliche Sitzung am 29 Mai, 1852. 8vo. 1852.
*Philosophisch-Historische Classe:*—
Sitzungsberichte, Band VIII. Hefte 3 und 4. Band IX. Hefte 1 und 2. 8vo. 1852.
Archiv für Kunde Œsterreichischer Geschichtsquellen, Band VIII. 8vo. 1852.
Notizenblatt. (Beilage zum Archiv.) No. 11-24. 8vo. 1852.
Das Verbrüderungs-Buch des Stiftes S. Peter zu Salzburg aus dem achten bis dreizehnten Jahrhundert, mit Erläuterungen von Th. G. v. Karajan fol. 1852.
*Mathematisch-Naturwissenschaftliche Classe:*—
Denkschriften, Band III. Lieferung 2. Band IV. Lieferung 2. 4to. 1852-3.
Sitzungsberichte, Band VIII. Hefte 4 und 5. Band IX. Hefte 1 und 2. 8vo. 1852.
Die Vegetationsverhältnisse von Iglau. Ein Beitrag zur Pflanzen-geographie des Böhmisch-Märischen Gebirges, von Alois Pokorny. Mit einer Karte. 8vo. 1852.

*Farrer, James Wm. Esq. M.R.I.*—Y Gododin.—A Poem on the Battle of Cattraeth, by Aneurin, a Welsh Bard of the Sixth Century, with an English Translation and Notes by the Rev. J. Williams ab Ithel. 8vo. 1852.
*Forbes, John, M.D., F.R.S., M.R.I. (the Author)* — Memorandums made in Ireland in the Autumn of 1852. 2 vols. 16mo. 1853.
*Geological Society* — Quarterly Journal, No. 34. 8vo. 1853.
*Lovell, E. B. Esq. M.R.I. (the Editor)* — The Common Law and Equity Reports, Part 2. 8vo. 1853.
*Perigal, H. Jun. Esq. (the Author)* — Geometric Maps exhibiting the Method of Delineating Curves through the Intersection of Trigonometric Lines.
*Prosser, John, Esq. Life-Sub. R.I.* — M. T. Ciceronis Sex Orationum Fragmenta inedita, cum Commentariis Antiquis item ineditis invenit, recensuit, notis illustravit Angelus Maius. 8vo. 1816.
*Royal Society*—Proceedings, No. 95. 8vo. 1853.
Transactions, 1853. Part 1. 4to. 1853.
Address of the President, Nov. 30, 1852. 1853.
*Society of Arts*—Journal, Nos. 25, 26, 27. 8vo. 1853.
*Stanley, Lord (the Author)*—The Church Rate Question considered. 8vo. 1853.
*Statistical Society of London* — Journal, Vol. XVI. Part 2. 8vo. 1853.
*Taylor, Rev. W. F.R.S., M.R.I.*—Lachegern's Haus- und Lach-Apotheke. 16mo. Grätz, 1836.
Das Goldmacherdorf. Von H. Zschokke. 16mo. Aarau, 1843.
P. M. Imhof's Anleitung zur Naturlehre. Aus dem Latein ins Deutsches übersetzt von J. G. Prändel. 8vo. Amberg, 1802.
Der närrische Vormund; von F. Laun. 16mo. Leipzig, 1831.
Schauderhafte Begebenheiten des Bürgerkrieges zu Zippelzelle. Von Ferdinand Döring. 16mo. Leipzig, 1826.
*Vigne, Godfrey, Esq. M.R.I.*— Photograph of a Zodiacal Stone (otherwise "Montezuma's Watch") from Mexico.
*Weale, John, Esq. (the Publisher)* — A Treatise on Gas-works, by S. Hughes. C. E. 12mo. 1853.
*Zoological Society*—Transactions, Vol. IV. Part 3. 4to. 1853.
Proceedings, Nos. 201-217, and 219-226. 8vo. 1850-1.

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## WEEKLY EVENING MEETING,

Friday, June 10.

THE DUKE OF NORTHUMBERLAND, K.G., F.R.S., President, in the Chair.

PROFESSOR FARADAY,

### *MM. Boussingault, Frémy, Becquerel, &c. on Oxygen.*

THE object of the speaker was to bring before the Members, in the first place, M. Boussingault's endeavours to procure pure oxygen from the atmosphere in large quantities; so that being stored up in gasometers it might afterwards be applied to the many practical and

useful purposes which suggest themselves at once, or which may hereafter be developed. The principle of the process is to heat baryta in close vessels and peroxidize it by the passage of a current of air; and afterwards by the application of the same heat, and a current of steam (with the same vessels) to evolve the extra portion of oxygen, and receive it in fitly adjusted gasometers: then the hydrated baryta so produced is dehydrated by a current of air passed over it at a somewhat higher temperature, and finally oxidized to excess by the continuance of the current and a lower temperature:—and thus the process recurs again and again. The causes of failure in the progress of the investigation were described as detailed by M. Boussingault; the peculiar action of water illustrated; the reason why a mixture of baryta and lime, rather than pure baryta, should be used, was given; and the various other points in the *Mémoire* of M. Boussingault* noticed in turn. That philosopher now prepares the oxygen for his laboratory use by the baryta process.

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The next subject consisted of the recent researches of MM. Frémy and E. Becquerel, on the influence of the electric spark in converting pure dry oxygen into ozone. The electric discharge from different sources produces this effect, but the high intensity spark of the electric machine is that best fitted for the purpose. When the spark contains the same electricity, its effect is proportionate to its length; for at two places of discharge in the same circuit, but with intervals of 1 and 2, the effect in producing ozone is as 1 and 2 also. A spark can act by *induction;* for, when it passes on the *outside* a glass tube containing within dry oxygen, and hermetically sealed, the oxygen is partly converted into ozone. Using tubes of oxygen, which either stood over a solution of iodide of potassium or, being hermetically sealed, contained the metal silver, the oxygen converted into ozone was absorbed; and the conversion of the *whole* of a given quantity of oxygen into ozone could be thus established. The effect for each spark is but small; 500,000 discharges were required to convert the oxygen in a tube about 7 inches long and 0.2 in diameter into ozone. For the details of this research, see the Annales de Chimie, 1852, xxxv. 62.

Mr. Faraday then referred briefly to the recent views of Schönbein respecting the probable existence of part of the oxygen in oxy-compounds in the ozone state. Thus of the peroxide of iron, the third oxygen is considered by him as existing in the state of ozone; and of the oxygen in pernitrous acid, half, or the two latter proportions added when the red gas if formed from oxygen and nitrous gas, are supposed to be in the same state. Hence the peculiar chemical action of these bodies; which seems not to be accounted for by the

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* Annales de Chimie, 1852, xxxv. p. 1.

idea of a bare adhesion of the last oxygen, inasmuch as a red heat cannot separate the third oxygen from the peroxide of iron; and hence also, according to M. Schönbein, certain effects of change of colour by heat, and certain other actions connected with magnetism, &c. [M. F.]

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## GENERAL MONTHLY MEETING,

Monday, July 4.

WILLIAM POLE, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

Joseph Hayes, Esq.
Rear-Admiral J. Roberts Gawen

were duly *elected* Members of the Royal Institution.

JOHN TYNDALL, Esq., Ph.D., F.R.S., was unanimously elected Professor of Natural Philosophy in the Royal Institution.

The following PRESENTS were announced, and the thanks of the Members ordered to be returned for the same:—

FROM

*Airy, G. B. Esq. F.R.S. Astronomer Royal (the Author)* — Address to the Individual Members of the Board of Visitors of the Royal Observatory, Greenwich; by the Astronomer-Royal, and his Report read at the Annual Visitation, June 4, 1853. 4to. 1853.

*Astronomical Society, Royal* — Monthly Notices, Vol. XIII. No. 7. 8vo. 1853.

*Bell, Jacob, Esq. (the Editor)* — The Pharmaceutical Journal for June, 1853. 8vo.

*Bengal, Council of Education* — Annual Report of the Medical College of Bengal, Session 1852-3. 8vo. Calcutta, 1853.

*Blackwell, J. Kenyon, Esq., F.G.S. (the Author)* — Explosions in Coal Mines, their Causes, and the Means available for their Prevention and Control. 8vo. 1853.

*British Architects, Royal Institute of,* — Proceedings, June, 1853. 4to.

*Cocks, Messrs. (the Publishers)* — Cocks' Musical Miscellany, June, 1853. 4to.

*Editors* — The Athenæum for May, 1853. 4to.

The Practical Mechanic's Journal, June, 1853. 4to.

The Medical Circular, June, 1853. 4to.

*Faraday, Professor, F.R.S. &c.* — Mémoires de l'Académie des Sciences de l'Institut de France. Tome XXIII. 4to. Paris, 1853.

Mémoires de l'Académie des Sciences Morales et Politiques de l'Institut de France. Tome VIII. 4to. Paris, 1853.

*Franklin Institute of Pennsylvania* — Journal, Vol. XXII. No. 6; Vol. XXIV. No. 6; Vol. XXV. No. 4. 8vo. 1851-3.

*Her Majesty's Government (by Col. E. Sabine)* — Observations made at the Magnetical and Meteorological Observatory at Hobarton, in Van Diemen Island. Vol. III. 4to. 1853.

*Hind, J. Russell, Esq. (the Superintendant)* — The Nautical Almanac for 1854, 1855, 1856. 8vo. 1851-3.

*London Institution, Managers of the* — Catalogue of the Library of the London Institution, Vol. IV. 8vo. 1852.

*London, Committee of the Library of the Corporation of the City of* — A Descriptive Catalogue of the London Traders' Tavern and Coffee House Tokens current in the 17th Century; presented to the Corporation Library by H. B. H. Beaufoy, Esq. By J. H. Burn. 8vo. 1853.

*Lovell, E. B. Esq. (the Editor)* — The Monthly Digest, June, 1853. 8vo.

The Common Law and Equity Reports. Vol. I. Part 3. 8vo. 1853.

*Novello, Messrs. (the Publishers)* — The Musical Times, June, 1853.

*Oldfield, David, Esq. M.R.I.* — Illustrations of the Remains of Roman Art in Cirencester, the site of the Ancient Corinium. By Professor Buckman, F.L.S. &c., and C. H. Newmarch, Esq. 4to. 1850.

*Royal Society of London* — Proceedings, No. 96. 8vo. 1853.

*Society of Arts* — Journal, Nos. 28, 29, 30, 31. 8vo. 1853.

*Taylor, Rev. W., F.R.S., M.R.I.* — Remarks on a Gold Ring found at Wormleighton, Warwickshire. By W. B. Dickinson, Esq. 8vo. 1851.

Report of the Bristol Blind Asylum for 1852. 12mo. 1853.

*Twining, Miss Louisa* — Symbols and Emblems of Early and Mediæval Christian Art. By Louisa Twining. 4to. 1852.

Crétins and Idiots — A short Account of the Progress of the Institutions for their Relief and Cure. 8vo. 1853.

*Vereins zur Beförderung des Gewerbfleisses in Preussen* — Verhandlungen, März und April, 1853. 4to. Berlin, 1853.

*Watson, Henry, Esq. M.R.I.* — Hints on the Establishment of Public Industrial Schools for the Working Classes. By the Rev. John Sedgwick, M.A. 8vo. 1853.

*Wrottesley, The Lord, V.P.R.S. (the Author)* — Speech in the House of Lords on 26th April, 1853, on Lieut. Maury's Plan for Improving Navigation, with some Remarks upon the advantages arising from the Pursuit of Abstract Science. 8vo. 1853.

[FOR THE USE OF MEMBERS.]

# Royal Institution of Great Britain.



## 1853.

### GENERAL MONTHLY MEETING,

Monday, November 7.

WILLIAM POLE, ESQ., M.A., F.R.S., Treasurer and Vice-President, in the Chair.

The following PRESENTS were announced, and the thanks of the Members returned for the same;—

FROM

*Her Majesty's Government (by Col. E. Sabine)* — Magnetical and Meteorological Observations at Toronto. Vol. II. 1843-5. 4to. 1853.
Catalogue of Stars near the Ecliptic, observed at Markree in 1851-2. Vol. II. 1853.
*Actuaries, Institute of* — List of Members. 1853. Constitution and Laws. 1853.
The Assurance Magazine, No. 12, 13. 8vo. 1853.
*Agricultural Society of England, Royal* — Journal, Vol. XIII. Part 2, and Vol. XIV. Part 1. 8vo. 1852-3.
*American Philosophical Society* — Proceedings, No. 48. 8vo. 1852.
*Antiquaries, Society of* — Archæologia, Vol. XXXV. Part 1. 4to. 1853.
Proceedings, Nos. 33—36. 8vo. 1852-3.
List of Fellows, 1853. 8vo.
Catalogue of the Kerrich Collection of Roman Coins. 8vo. 1852.
*Asiatic Society of Bengal* — Journal, Nos. 232—235. 8vo. 1853.
Catalogue of the Birds in the Museum of the Asiatic Society, Calcutta. By E. Blyth. 8vo. Calcutta, 1849.
*Asiatic Society, Royal* — Journal, Vol. XV. Part 1. 8vo. 1853.
*Astronomical Society, Royal* — Monthly Notices, Vol. XIII. No. 89. 8vo. 1853.
Memoirs, Vol. XXI. 4to. 1852-3.
*Bache, Dr. A. D. (the Superintendent)* — United States Coast Survey, 5 sheets.
*Bayerische Akademie* — Abhandlungen der Mathemat.-Physikalischen Classe. Band VII. Abtheilung 1. 4to. München, 1853.
Bulletins, 1852, No 25-29. 4to. 1852.
*Bell, Jacob, Esq. (the Editor)* — The Pharmaceutical Journal, July to Nov. 1853. 8vo.
*Boston Society of Natural History* — Journal, Vol. IV. No. 2; Vols. V. and VI. No. 1 and 2, 8vo. Boston, U. S. 1842-50.
Proceedings, Vols. I. II. III., and Vol. IV. No. 1—14. 8vo. Boston, U. S. 1841-52.
*British Association for the Advancement of Science* — Report of the Twenty-second Meeting, at Belfast, Sept. 1852. 8vo. 1853.
*British Architects, Royal Institute of* — Proceedings, July 1853. 4to.
*Chemical Society* — Quarterly Journal, No. 22, 23. 8vo. 1853.

*Clarendon, Right Hon. the Earl of, K.G., G.C.B. &c.*—Grammar of the Bornu or Kanuri Language; with Dialogues, Translations, and Vocabulary, by Edwin Norris. 8vo. 1853.

Dialogues and a small portion of the New Testament in the English, Arabic, Haussa, and Bornu Languages. Obl. folio. 1853.

*Colt, Col. Samuel (the Author)*—On the application of Machinery to the Manufacture of Rotating Chamber-Breeched Fire-arms. 8vo. 1853.

*Commissioners in Lunacy*—Seventh Annual Report to the Lord Chancellor, 30th June, 1852. 8vo. 1853.

*Cornwall Polytechnic Society, Royal*—Annual Report, for 1852. 8vo.

*De la Rive, M. Auguste, (the Author)*—François Arago. 8vo. 1853.

*Editors*—The Athenæum for June to Oct. 1853. 4to.

The Medical Circular, July to Oct. 1853. 4to.

The Practical Mechanic's Journal, July to Nov. 1853. 4to.

The Journal of Gas-Lighting, Vol. II. and No. 48—58. Folio, 1851-3.

*Faraday, M. Esq., F.R.S., &c.*—Monatsberichte der Königl. Preuss. Akademie, April zu August, 1853. 8vo. Berlin.

Abhandlungen der Königliche Akademie der Wissenschaften zu Berlin, 1852. 4to. 1853.

Kaiserliche Akademie der Wissenschaften, Wien:—

*Philosophisch-Historische Classe:*—

Denkschriften, Band IV. 4to. 1853.

Sitzungsberichte, Band IX. Hefte 3, 4, 5. Band X. Hefte 1, 2, 3. 8vo. 1852-3.

Archiv für Kunde Œsterreichischer Geschichts-quellen. Band IX. 8vo. 1853.

Fontes Rerum Austriacarum. Zweite Abtheilung. Band V. und VI. 8vo. 1852-3.

*Mathematisch-Naturwissenschaftliche Classe:*—

Denkschriften. Band V. Lieferung 1. 4to 1853.

Sitzungsberichte, Band IX. Hefte 3, 4, 5. Band X. Hefte 1, 2, 3. 8vo. 1852-3.

*Franklin Institute of Pennsylvania*—Journal, Vol. XXV. No. 1 and 6. Vol. XXVI. No. 1, 2, and 3. 8vo. 1853.

*Geological Society*—Journal, No. 35, 36. 8vo. 1853.

*Geographical Society, Royal*—Address at the Anniversary Meeting, May 23, 1853, by Sir R. I. Murchison, President. 8vo. 1853.

*Greenwich Royal Observatory*—Astronomical, Magnetical, and Meteorological Observations at Greenwich in 1851. 4to. 1853.

*Halliwell, J. O. Esq., F.R.S., (the Author)*—Curiosities of Modern Shakspearian Criticism. 8vo. 1853.

*Horticultural Society of London*—Journal, Vol. VIII. Parts 3, 4. 8vo. 1853.

*Jones, H. Bence, M.D., F.R.S., M.R.I. (the Author)*—On the Dissolution of Urinary Calculi in Dilute Saline Fluids, at the Temperature of the Body, by the aid of Electricity. (From Phil. Trans. Royal Soc.) 4to. 1853.

On Sig. Carlo Matteucci's Letter to H. B. Jones, M.D., by Emil Du Bois-Reymond. 8vo. 1853.

*Linnean Society of London*—Transactions, Vol. XXI. Part 2. 4to. 1853.

Proceedings, No. 48—51. 8vo. 1851-2.

List of Members, 1852. 8vo.

*Lovell, E. B. Esq., M.R.I. (the Editor)*—The Monthly Digest for July—Oct. 1853. 8vo.

Common Law and Equity Reports in all the Courts, Vol. I. Parts 4, 5. 8vo. 1853.

*Lubbock, John, Esq., F.Z.S., M.R.I. (the Author)*—On two new Species of Calanidæ. 8vo. 1853.

*Macilwain, George, Esq., F.R.S., M.R.I. (the Author).*—Memoirs of John Abernethy, F.R.S., with a View of his Lectures, Writings, and Character. 2 vols. 16mo. 1853.

*Newcastle-upon-Tyne, Literary and Philosophical Society of*—Catalogue of the Library. 8vo. 1848.
*Norton, Mr. C. B. (the Publisher)*—Norton's Literary Register for 1853. New York. 16mo. 1853.
*Novello, Messrs. (the Publishers)*—The Musical Times, for July—Oct. 1853. 4to.
*Oldfield, D. Esq., M.R.I.*—Observations on Mr. L. W. Wright's Patent Inventions, &c. By D. King, M.D. 16mo. 1853.
*Oliveira, B. Esq., M.P., F.R.S., M.R.I.*—Essay on the Resources of Portugal. 8vo. 1853.
Ensaio sobre Portugal em relaçao aos objectos da Grande Expoziçao. 8vo. 1853.
*Pathological Society of London*—Transactions. Vol. IV. 8vo. 1853.
*Petermann, Augustus, Esq. (the Author)*—Historical Summary of the Search for Sir John Franklin, 1848—53. 8vo. 1853.
Die letzten Tage Dr. Adolf Overwegs. 8vo. 1853.
*Photographical Society*—Journal, No. 1—10. 8vo. 1853.
*Physicians, Royal College of, London*—Catalogue of Fellows, Licentiates, and Extra Licentiates. 1853.
*Radcliffe Trustees, Oxford*—Astronomical Observations made at the Radcliffe Observatory in 1851. By M. Johnson, M.A. 8vo. 1853.
*Royal Society*—Proceedings, No. 97. 8vo. 1853.
*Smithsonian Institution*—Sixth Annual Report, for the year 1851. 8vo. Washington, 1852.
Smithsonian Contributions to Knowledge, Vol. V. 4to. Washington. 8vo. 1853.
Catalogue of Portraits of North American Indians, painted by J. Stanley, deposited with the Smithsonian Institution. 8vo. Washington, 1852.
*Smith, Mr. J. Russell (the Publisher)*—The Retrospective Review, No. 4 and 5. 8vo. 1853.
*Society of Arts*—Journal, No. 32—50. 8vo. 1853.
*Statistical Society of London*—Journal, Vol. XVI. Part 3. 8vo. 1853.
List of Fellows. 8vo. 1853.
*Surgeons, Royal College of England*—List of Fellows, &c. 8vo. 1853.
*Taylor, Rev. W., F.R.S., M.R.I.*—The Construction of the Modern System; consisting of Six Drawings as executed at Sandhurst and Addiscombe, with Instructions. By T. Kimber. 8vo. 1852.
Anglo-Saxon Relics from West Stow Heath. By S. Tymms, Esq. 8vo. 1853.
An Introduction to Practical Astronomy, by the Rev. W. Pearson, Vol. I. 4to. 1824.
Herr Immerlustig, eine Sammlung der Witzspiele und Anekdoten. 16mo. München, 1841.
Rosa Von Tannenburg. Eine Geschichte des Alterthums. Von Ch. von Schmid. 16mo. Augsburg, 1845.
*Thimm, Mr. F. (the Publisher)*—Deutsches Athenäum für 1853. 4to.
*Tyndall, Prof. J., F.R.S., &c. (the Author.)*—On Molecular Influences, Part I. Transmission of Heat through Organic Structures. (From Phil. Trans. Roy. Soc.) 4to. 1853.
*Vereins zur Beförderung des Gewerbfleisses in Preussen*—Verhandlungen, Mai und Juni, 1853. 4to. Berlin.
*Vincent, B., Assist. Sec. R. I.*—Essay on Musical Expression. By C. Avison; also a Letter to the Author on the Music of the Ancients, &c. 16mo. 1775.
*Visitors of Hanwell Lunatic Asylum*—Reports. 8vo. 1842-53.
*Weale, John, Esq. (the Publisher)*
Rudimentary Treatises:
Agricultural Engineering. By G. H. Andrews. Vol. III. 12mo. 1853.
Masting, Mast-making, and Rigging of Ships. By R. Kipping, N.A. 12mo 1853.

*Weale, John, Esq. (the Publisher)*
Construction of Locks. By A. Hobbs. Edited by C. Tomlinson. 12mo. 1853.
Steam and Locomotion. By John Sewell, L. E. Vol. II. 12mo. 1853.
Astronomical Annual for 1854. 12mo. 1853.
Dictionary of English, German, and French Languages. Part I. By N. E. Hamilton. 12mo. 1853.
Grammar of the French Language. By G. L. Strauss, Ph. D. 12mo. 1853.
Outlines of the History of England. By W. D. Hamilton. Vol. II. 12mo. 1853.
*Wilson, Mr. C.*—An Atlas of 34 Large Maps. Folio. 1745—85.

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## GENERAL MONTHLY MEETING,

Monday, Dec. 5.

William Pole, Esq., M.A., F.R.S., Treasurer and Vice-President, in the Chair.

Joseph Collis, Esq. Benjamin Gray, Esq.
John Ferguson, M.D. Thomas Spencer Wells, Esq., F.R.C.S.

were duly *elected* Members of the Royal Institution.

The Secretary reported that the following Arrangements had been made for the Lectures before Easter, 1854:

Six Lectures on Voltaic Electricity (adapted to a Juvenile Auditory)—by Michael Faraday, Esq., D.C.L., F.R.S., &c., Fullerian Professor of Chemistry, R.I.

Twelve Lectures on Heat—by John Tyndall, Esq., Ph. D., F.R.S., Professor of Natural Philosophy R.I.

Twelve Lectures on Animal Physiology—by T. Wharton Jones, Esq. F.R.S., Fullerian Professor of Physiology, R.I.

Twelve Lectures on the Chemistry of the Non-Metallic Elements—by W. A. Miller, M.D., F.R.S., Professor of Chemistry, King's College, London.

The following Presents were announced, and the thanks of the Members returned for the same;—

From

*Bell, Jacob, Esq.*—The Pharmaceutical Journal, Dec. 1853. 8vo.
*Betts, Mr. John,*—Capt. M'Clure's Despatches from Her Majesty's Discovery Ship, Investigator, off Point Warren and Cape Bathurst. 8vo. 1853.
*British Architects, Royal Institute of*—Proceedings in Nov. 1853.
*Civil Engineers, Institution of*—Proceedings in Nov. 1853. 8vo.
*De la Beche, Sir Henry*—Lecture on the Educational Uses of Museums. By E. Forbes, F.R.S. 8vo.
*Editors*—The Medical Circular for Nov. 1853. 8vo.
The Athenæum, Nov. 1853. 4to.
The Practical Mechanic's Journal, Dec. 1853. 4to.

*Faraday, Professor* — Bulletin de la Classe Physico-Mathématique de l'Académie Impériale des Sciences de Saint-Pétersbourg. Tome XI. 4to. 1853.
Memorie della Reale Accademia delle Scienze di Torino. Serie Seconda. Tomo XIII. 4to. Torino, 1853.
*Forrester, Joseph J. Esq.* (*the Author*) — The Oliveira Prize-Essay on Portugal. (With a Map of the Wine Districts of the Alto-Douro.) 8vo. 1853.
*Graham, George, Esq.* (*Registrar-General*) — Tenth, Eleventh, and Twelfth Reports of the Registrar-General. 8vo. 1852-3.
*Lovell, E. B. Esq.* (*the Editor*) — The Monthly Digest for Dec. 1853. 8vo.
The Common Law and Equity Reports in all the Courts, Vol. I. Part 6. 8vo. 1853.
*Lubbock, John, Esq., F.Z.S., M.R.I.* (*the Author*) — On Two New Species of Calanidæ. 8vo. 1853.
*Macloughlin, David, M.D., M.R.I.* — Procés-Verbaux de la Conférence Sanitaire Internationale ouverte à Paris le 27 Juillet, 1851. folio. Paris. 1852.
*Medical and Chirurgical Society, Royal* — Medico-Chirurgical Transactions, Vol. XXXVI. 8vo. 1853.
*Moxon, Edward, Esq. M.R.I.* — Poems of Wit and Humour. By T. Hood. 16mo. 1853.
*Novello, Messrs.* — The Musical Times, Dec. 1853. 4to.
*Photographic Society* — Journal, No. 11. 8vo. 1853.
*Royal Society of Edinburgh* — Transactions, Vol. XX. Part 4. 4to. 1853.
Proceedings, No. 43. 8vo. 1852-3.
*Society of Arts* — Journal, No. 51-54. 8vo. 1853.
*Vereins zur Beförderung des Gewerbfleisses in Preussen* — Verhandlungen, Juli und August, 1853. 4to. Berlin.
*Webster, John M.D., F.R.S., M.R.I.,* — Physicians' Report of the Royal Hospital of Bethlem for 1846. 8vo.
General Reports of the Royal Hospitals of Bridewell and Bethlem and of the House of Occupations, 1848-52. 8vo.

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# 1854.

## WEEKLY EVENING MEETING,

Friday, January 20.

Right Hon. BARON PARKE, Vice-President, in the Chair.

PROFESSOR FARADAY, D.C.L., F.R.S.

### *On Electric Induction — Associated cases of current and static effects.*

CERTAIN phenomena that have presented themselves in the course of the extraordinary expansion which the works of the Electric Telegraph Company have undergone, appeared to me to offer

remarkable illustrations of some fundamental principles of Electricity, and strong confirmation of the truthfulness of the view which I put forth sixteen years ago, respecting the mutually dependent nature of induction, conduction, and insulation (Experimental Researches, 1318, &c.). I am deeply indebted to the Company; to the Gutta Percha works, and to Mr. Latimer Clarke, for the facts; and also for the opportunity both of seeing and shewing them well.

Copper wire is perfectly covered with gutta percha at the Company's works, the metal and the covering being in every part regular and concentric. The covered wire is usually made into half mile lengths, the necessary junctions being effected by twisting or binding, and ultimately, soldering; after which the place is covered with fine gutta percha, in such a manner as to make the coating as perfect there as elsewhere: the perfection of the whole operation is finally tried in the following striking manner, by Mr. Statham, the manager of the works. The half mile coils are suspended from the sides of barges floating in a canal, so that the coils are immersed in the water whilst the two ends of each coil rise into the air: as many as 200 coils are thus immersed at once, and when their ends are connected in series, one great length of 100 miles of submerged wire is produced, the two extremities of which can be brought into a room for experiment. An insulated voltaic battery of many pairs of zinc and copper, with dilute sulphuric acid, has one end connected with the earth and the other, through a galvanometer, with either end of the submerged wire. Neglecting the first effect, but continuing the contact, it is evident that the battery current can take advantage of the whole accumulated conduction or defective insulation in the 100 miles of gutta percha on the wire, and that whatever portion of electricity passes through to the water will be shewn by the galvanometer. Now the battery is made one of intensity, in order to raise the character of the proof, and the galvanometer employed is of considerable delicacy; yet so high is the insulation that the deflection is not more than 5°. As another test of the perfect state of the wire, when the two ends of the battery are connected with the two ends of the wire, there is a powerful current of electricity shewn by a much coarser instrument; but when any one junction in the course of the 100 miles is separated, the current is stopped, and the leak or deficiency of insulation rendered as small as before. The perfection and condition of the wire may be judged of by these facts.

The 100 miles, by means of which I saw the phenomena, were thus good as to insulation. The copper wire was $\frac{1}{16}$ of an inch in diameter:—the covered wire was $\frac{4}{16}$; some was a little less, being $\frac{7}{32}$ in diameter:—the gutta percha on the metal may therefore be considered as 0.1 of an inch in thickness. 100 miles of like covered wire in coils were heaped up on the floor of a dry warehouse and connected in one series, for comparison with that under water.

Consider now an insulated battery of 360 pairs of plates (4 × 3 inches) having one extremity in contact with the earth, the water wire with both its insulated ends in the room, and a good earth discharge wire ready for the requisite communications:—when the free battery end was placed in contact with the water wire and then removed, and, afterwards, a person touching the earth discharge touched also the wire, he received a powerful shock. The shock was rather that of a voltaic than of a Leyden battery: it occupied *time*, and by quick tapping touches could be divided into numerous small shocks: I obtained as many as 40 sensible shocks from one charge of the wire. If *time* were allowed to intervene between the charge and discharge of the wire, the shock was less: but it was sensible after 2, 3, or 4 minutes, or even a longer period.

When, after the wire had been in contact with the battery, it was placed in contact with a Statham's fuze, it ignited the fuze (or even 6 fuzes in succession) vividly: — it could ignite the fuze 3 or 4 seconds after separation from the battery. When, having been in contact with the battery, it was separated and placed in contact with a galvanometer, it affected the instrument very powerfully: — it acted on it, though less powerfully, after the lapse of 4 or 5 minutes, and even affected it sensibly 20 or 30 minutes after it had been separated from the battery. When the insulated galvanometer was permanently attached to the end of the water wire, and the battery pole was brought in contact with the free end of the instrument, it was most instructive to see the great rush of electricity into the wire; yet after that was over, though the contact was continued, the deflection was not more than 5°, so high was the insulation. Then separating the battery from the galvanometer, and touching the latter with the earth wire, it was just as striking to see the electricity rush out of the wire, holding for a time the magnet of the instrument in the reverse direction to that due to the ingress or charge.

These effects were produced equally well with either pole of the battery or with either end of the wire; and whether the electric condition was conferred and withdrawn at the same end or at the opposite ends of the 100 miles, made no difference in the results. An intensity battery was required, for reasons which will be very evident in the sequel. That employed was able to decompose only a very small quantity of water in a given time. A Grove's battery of 8 or 10 pair of plates, which would have far surpassed it in this respect, would have had scarcely a sensible power in affecting the wire.

When the 100 miles of wire in the air were experimented with in like manner, not the slightest signs of any of these effects were produced. There is reason, from principle, to believe that an infinitesimal result is obtainable, but as compared to the water wire the action was nothing. Yet the wire was equally well and better insulated, and as regarded a constant current, it was an

equally good conductor. This point was ascertained, by attaching the end of the water wire to one galvanometer, and the end of the air wire to another like instrument; the two other ends of the wires were fastened together, and to the earth contact; the two free galvanometer ends were fastened together, and to the free pole of the battery: in this manner the current was divided between the air and water wires, but the galvanometers were affected to precisely the same amount. To make the result more certain, these instruments were changed one for the other, but the deviations were still alike: so that the two wires conducted with equal facility.

The cause of the first results is, upon consideration, evident enough. In consequence of the perfection of the workmanship, a Leyden arrangement is produced upon a large scale: the copper wire becomes charged statically with that electricity which the pole of the battery connected with it can supply;* it acts by induction through the gutta percha (without which induction it could not itself become charged, Exp. Res. 1177), producing the opposite state on the surface of the water touching the gutta percha, which forms the outer coating of this curious arrangement. The gutta percha across which the induction occurs, is only 0.1 of an inch thick, and the extent of the coating is enormous. The surface of the copper wire is nearly 8300 square feet, and the surface of the outer coating of water is four times that amount, or 33000 square feet. Hence, the striking character of the results. The intensity of the static charge acquired is only equal to the intensity at the pole of the battery whence it is derived; but its quantity is enormous, because of the immense extent of the Leyden arrangement; and hence when the wire is separated from the battery and the charge employed, it has all the powers of a considerable voltaic current, and gives results which the best ordinary electric machines and Leyden arrangements cannot as yet approach.

That the air wire produces none of these effects is simply because there is no outer coating correspondent to the water, or only one so far removed as to allow of no sensible induction, and therefore the inner wire cannot become charged. In the air wire of the warehouse, the floor, walls, and ceiling of the place constituted the outer coating, and this was at a considerable distance; and in any case could only affect the outside portions of the coils of wire. I understand that 100 miles of wire stretched in a line through the air, so as to have its whole extent opposed to earth, is equally inefficient in shewing the effects, and there it must be the distance of the inductric and inducteous surfaces (1483), combined with the lower specific inductive capacity of air, as compared with gutta percha, which causes the negative result. The phenomena alto-

* Davy, Elements of Chemical Philosophy, p. 154.

gether offer a beautiful case of the identity of static and dynamic electricity. The whole power of a considerable battery may in this way be worked off in separate portions, and measured out in units of static force, and yet be employed afterwards for any or every purpose of voltaic electricity.

I now proceed to further consequences of associated static and dynamic effects. Wires covered with gutta percha, and then inclosed in tubes of lead or of iron, or buried in the earth, or sunk in the sea, exhibit the same phenomena as those described; the like static inductive action being in all these cases permitted by the conditions. Such subterraneous wires exist between London and Manchester, and when they are all connected together so as to make one series, offer above 1500 miles; which, as the duplications return to London, can be observed by one experimenter at intervals of about 400 miles, by the introduction of galvanometers at these returns. This wire, or the half, or fourth of it, presented all the phenomena already described; the only difference was, that as the insulation was not so perfect, the charged condition fell more rapidly. Consider 750 miles of the wire in one length, a galvanometer *a* being at the beginning of the wire, a second galvanometer *b* in the middle, and a third *c* at the end:—these three galvanometers being in the room with the experimenter, and the third *c* perfectly connected with the earth. On bringing the pole of the battery into contact with the wire through the galvanometer *a*, that instrument was instantly affected; after a sensible time *b* was affected, and after a still longer time *c*: when the whole 1500 miles were included, it required two seconds for the electric stream to reach the last instrument. Again;—all the instruments being deflected, (of course not equally because of the electric leakage along the line,) if the battery were cut off at *a*, that instrument instantly fell to zero; but *b* did not fall until a little while after; and *c* only after a still longer interval;—a current flowing on to the end of the wire whilst there was none flowing in at the beginning. Again; by a short touch of the battery pole against *a*, it could be deflected and could fall back into its neutral condition, before the electric power had reached *b*; which in its turn would be for an instant affected, and then left neutral before the power had reached *c*; a wave of force having been sent into the wire which gradually travelled along it, and made itself evident at successive intervals of time, in different parts of the wire. It was even possible, by adjusted touches of the battery, to have two simultaneous waves in the wire, following each other, so that at the same moment that *c* was affected by the first wave, *a* or *b* was affected by the second; and there is no doubt that by the multiplication of instruments and close attention, four or five waves might be obtained at once.

If after making and breaking battery contact at *a*, *a* be immediately connected with the earth, then additional interesting effects occur. Part of the electricity which is in the wire will return, and passing

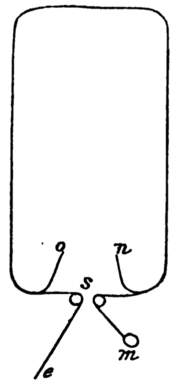
through *a* will deflect it in the reverse direction; so that currents will flow out of both extremities of the wire in opposite directions, whilst no current is going into it from any source. Or if *a* be quickly put to the battery and then to the earth, it will shew a current first entering into the wire, and then returning out of the wire at the same place; no sensible part of it ever travelling on to *b* or *c*.

When an air wire of equal extent is experimented with in like manner, no such effects as these are perceived: or if, guided by principle, the arrangements are such as to be searching, they are perceived only in a very slight degree, and disappear in comparison with the former gross results. The effect at the end of the very long air wire (or *c*) is in the smallest degree behind the effect at galvanometer *a*; and the accumulation of a charge in the wire is not sensible.

All these results as to *time*, &c. evidently depend upon the same condition as that which produced the former effect of static charge, namely, *lateral induction;* and are necessary consequences of the principles of conduction, insulation, and induction, three terms which in their meaning are inseparable from each other (Exp. Res. 1320, 1326,* 1338, 1561, &c.). If we put a plate of shell lac upon a gold leaf electrometer and a charged carrier (an insulated metal ball of two or three inches diameter) upon it, the electrometer is diverged; removing the carrier, this divergence instantly falls, this is *insulation* and *induction*: if we replace the shell lac by metal, the carrier causes the leaves to diverge as before, but when removed, though after the shortest possible contact, the electroscope is left diverged, this is *conduction*. If we employ a plate of spermaceti instead of the metal, and repeat the experiment, we find the divergence partly falls and partly remains, because the spermaceti insulates and also conducts, doing both imperfectly: but the shell lac also conducts, as is shewn if time be allowed; and the metal also obstructs conduction, and therefore insulates, as is shewn by simple arrangements. For if a copper wire, 74 feet in length and $\frac{1}{12}$ of

* 1326. All these considerations impress my mind strongly with the conviction, that insulation and ordinary conduction cannot be properly separated when we are examining into their nature: that is, into the general law or laws under which their phenomena are produced. They appear to me to consist in an action of contiguous particles, dependent on the forces developed in electrical excitement; these forces bring the particles into a state of tension or polarity, which constitutes both *induction* and *insulation*; and being in this state the contiguous particles have a power or capability of communicating these forces, one to the other, by which they are lowered and discharge occurs. Every body appears to discharge (444.987); but the possession of this capability in a *greater or smaller degree* in different bodies, makes them better or worse conductors, worse or better insulators: and both *induction* and *conduction* appear to be the same in their principle and action (1320), except that in the latter, an effect common to both is raised to the highest degree, whereas in the former, it occurs in the best cases, in only an almost insensible quantity.

an inch in diameter, be insulated in the air, having its end *m* a metal ball; its end *e* connected with the earth, and the parts near *m* and *e* brought within half an inch of each other, as at *s*; then an ordinary Leyden jar being charged sufficiently, its outside connected with *e* and its inside with *m*, will give a charge to the wire, which instead of travelling wholly through it, though it be so excellent a conductor, will pass in large proportion through the air at *s*, as a bright spark: for with such a length of wire, the resistance in it is accumulated until it becomes as much, or perhaps even more, than that of the air, for electricity of such high intensity.




Admitting that such and similar experiments shew that conduction through a wire is preceded by the act of induction (1338), then all the phenomena presented by the submerged or subterranean wires are explained; and in their explanation confirm as I think, the principles given. After Mr. Wheatstone had, in 1834, measured the velocity of a wave of electricity through a copper wire, and given it as 288,000 miles in a second, I said, in 1838, upon the strength of these principles (1333,) "that the velocity of discharge through the *same wire* may be greatly varied, by attending to the circumstances which cause variations of discharge through spermaceti or sulphur. Thus, for instance, it must vary with the tension or intensity of the first urging force, which tension is charge and induction. So if the two ends of the wire, in Professor Wheatstone's experiment, were immediately connected with two large insulated metallic surfaces exposed to the air, so that the primary act of induction, after making the contact for discharge, might be in part removed from the internal portion of the wire at the first instant, and disposed for the moment on its surface jointly with the air and surrounding conductors, then I venture to anticipate, that the middle spark would be more retarded than before: and if these two plates were the inner and outer coating of a large jar, or a Leyden battery, then the retardation of that spark would be still greater[*]." Now this is precisely the case of the submerged or subterraneous wires, except that instead of carrying their surfaces towards the inducteous coatings (1483), the latter are brought near the former; in both cases the induction consequent upon charge, instead of being exerted almost entirely at the moment within the wire, is to a very large extent determined externally; and so the discharge or conduction being caused by a lower tension, therefore requires a longer time. Hence, the reason why, with 1500 miles of subterraneous wire, the wave was two seconds in passing from end to end; whilst with the same length of air wire, the time was almost inappreciable.

With these lights it is interesting to look at the measured velocities of electricity in wires of metal, as given by different experimenters.

| | Miles per second. |
|---|---|
| * Wheatstone in 1834, with copper wire made it | 288,000 |
| * Walker in America with telegraph iron wire - | 18,780 |
| * O' Mitchell, ditto. - ditto. - - | 28,524 |
| * Fizeau and Gonnelle (copper wire) - - | 112,680 |
| * Ditto. - - (iron wire) - - - | 62,600 |
| † A. B. G. (copper) London and Brussels Telegraph | 2,700 |
| † Ditto. (copper) London and Edinburgh Telegraph | 7,600 |

Here, the difference in copper is seen by the first and sixth result to be above a hundred fold. It is further remarked in Liebig's report of Fizeau's and Gonnelle's experiments, that the velocity is not proportional to the conductive capacity, and is independent of the thickness of the wire. All these circumstances and incompatibilities appear rapidly to vanish, as we recognise and take into consideration the lateral induction of the wire carrying the current. If the velocity of a brief electric discharge is to be ascertained in a given length of wire, the simple circumstances of the latter being twined round a frame in small space, or spread through the air through a large space, or adhering to walls, or lying on the ground, will make a difference in the results. And in regard to long circuits such as those described, their conducting power cannot be understood, whilst no reference is made to their lateral static induction, or to the conditions of intensity and quantity which then come into play; especially in the case of short or intermitting currents — for then static and dynamic are continually passing into each other.

It has already been said that the conducting power of the air and water wires are alike for a constant current. This is in perfect accordance with the principles and with the definite character of the electric force, whether in the static or current or transition state. When a voltaic current of a certain intensity is sent into a long water wire, connected at the further extremity with the earth, part of the force is in the first instance occupied in raising a lateral induction round the wire, ultimately equal in intensity at the near end to the intensity of the battery stream, and decreasing gradually to the earth end, where it becomes nothing. Whilst this induction is rising, that within the wire amongst its particles is beneath what it would otherwise be; but as soon as the first has attained its maximum state, then that in the wire becomes proportionate to the battery intensity, and therefore equals that in the air wire, in which the same state is (because of the

* Liebig and Kopp's Report, 1850 (translated), p. 168.
† Athenæum, 14th January, 1854, p. 54.

absence of lateral induction) almost instantly attained. Then of course they discharge alike and therefore conduct alike.

A striking proof of the variation of the conduction of a wire by variation of its lateral static induction, is given in the experiment proposed 16 years ago (1333.) If, using a constant charged jar, the interval *s*, page 6, be adjusted so that the spark shall freely pass there (though it would not if a little wider), whilst the short connecting wires *n* and *o* are insulated in the air, the experiment may be repeated twenty times without a single failure; but if after that, *n* and *o* be connected with the inside and outside of an insulated Leyden jar, as described, the spark will never pass across *s*, but all the charge will go round the whole of the long wire. Why is this? The quantity of electricity is the same, the wire is the same, its resistance is the same, and that of the air remains unaltered; but because the intensity is lowered, through the lateral induction momentarily allowed, it is never enough to strike across the air at *s*; and it is finally altogether occupied in the wire, which in a little longer time than before, effects the whole discharge. M. Fizeau has applied the same expedient to the primary voltaic currents of Ruhmkorff's beautiful inducting apparatus, with great advantage. He thereby reduces the intensity of these currents at the moment when it would be very disadvantageous, and gives us a striking instance of the advantage of viewing static and dynamic phenomena as the result of the same laws.

Mr. Clarke arranged a Bains' printing telegraph with three pens so that it gave beautiful illustrations and records of facts like those stated: the pens are iron wires, under which a band of paper imbued with ferro-prussiate of potassa passes at a regular rate by clock-work; and thus regular lines of prussian blue are produced whenever a current is transmitted, and the time of the current is recorded. In the case to be described, the three lines were side by side, and about 0.1 of an inch apart. The pen *m* belonged to a circuit of only a few feet of wire, and a separate battery; it told whenever the contact key was put down by the finger; the pen *n* was at the earth end of the long air wire, and the pen *o* at the earth end of the long subterraneous wire; and by arrangement, the key could be made to throw the electricity of the chief battery into either of these wires, simultaneously with the passage of the short circuit current through pen *m*. When pens *m* and *n* were in action, the *m* record was a regular line of equal thickness, shewing by its length the actual time during which the electricity flowed into the wires; and the *n* record was an equally regular line, parallel to, and of equal length with the former, but the least degree behind it; thus indicating that the long air wire conveyed its electric current almost instantaneously to the further end. But when pens *m* and *o* were in action, the *o* line did not begin until some time after the *m* line, and it continued after the *m* line had ceased *i. e.* after the *o* battery was cut off. Furthermore, it was faint at first, grew up to a maximum of intensity, continued at

that as long as battery contact was continued, and then gradually diminished to nothing. Thus the record *o* shewed that the wave of power took time in the water wire to reach the further extremity; by its first faintness, it shewed that power was consumed in the exertion of lateral static induction along the wire; by the attainment of a maximum and the after equality, it shewed when this induction had become proportionate to the intensity of the battery current; by its beginning to diminish, it shewed when the battery current was cut off; and its prolongation and gradual diminution shewed the time of the outflow of the static electricity laid up in the wire, and the consequent regular falling of the induction which had been as regularly raised.

With the pens *m* and *o* the conversion of an intermitting into a continuous current could be beautifully shewn; the earth wire by the static induction which it permitted, acting in a manner analogous to the fly wheel of a steam engine, or the air spring of a pump. Thus when the contact key was regularly but rapidly depressed and raised, the pen *m* made a series of short lines separated by intervals of equal length. After four or more of these had passed, then pen *o*, belonging to the subterraneous wire, began to make its mark, weak at first, then rising to a maximum, but always continuous. If the action of the contact key was less rapid, then alternate thickening, and attenuations appeared in the *o* record; and if the introductions of the electric current at the one end of the earth wire were at still longer intervals, the records of action at the other end became entirely separated from each other. All shewing most beautifully, how the individual current or wave, once introduced into the wire, and never ceasing to go onward in its course, could be affected in its intensity, its time, and other circumstances, by its partial occupation in static induction.

By other arrangements of the pens *n* and *o*, the near end of the subterraneous wire could be connected with the earth immediately after separation from the battery; and then the back flow of the electricity, and the time and manner thereof, were beautifully recorded; but I must refrain from detailing results which have already been described in principle.

Many variations of these experiments have been made and may be devised. Thus the ends of the insulated battery have been attached to the ends of the long subterraneous wire, and then the two halves of the wire have given back opposite return currents when connected with the earth. In such a case the wire is positive and negative at the two extremities, being permanently sustained by its length and the battery, in the same condition which is given to the short wire for a moment by the Leyden discharge (p. 351); or, for an extreme but like case, to a filament of shell lac having its extremities charged positive and negative. Colomb pointed out the difference of long and short as to the insulating or conducting power of such filaments, and like difference occurs with long and short metal wires.

The character of the phenomena described in this report, induces me to refer to the terms *intensity* and *quantity* as applied to electricity; terms which I have had such frequent occasion to employ. These terms, or equivalents for them, cannot be dispensed with by those who study both the static and the dynamic relations of electricity; every current where there is resistance has the static element and induction involved in it, whilst every case of insulation has more or less of the dynamic element and conduction; and we have seen that with the same voltaic source, the same current in the same length of the same wire, gives a different result as the intensity is made to vary, with variations of the induction around the wire. The idea of intensity or the power of overcoming resistance, is as necessary to that of electricity, either static or current, as the idea of pressure is to steam in a boiler, or to air passing through apertures or tubes: and being independent of the idea of quantity, we must have language competent to express both relations. Furthermore, I have never found either of these terms lead to any mistakes regarding electrical action, or give rise to any false view of the character of electricity or its unity. I cannot find other terms of equally useful significance with these; or any which, conveying the same ideas, are not liable to such misuse as these may be subject to. It would be affectation, therefore, in me, to search about for other words; and besides that, the present subject has shewn me more than ever their great value and peculiar advantage in electrical language.

[M. FARADAY.]

The fuze referred to in page 347, is of the following nature. Some copper wire was covered with sulphuretted gutta percha; after some months it was found that a film of sulphuret of copper was formed between the metal and the envelope; and further, that when half the gutta percha was cut away in any place, and then the copper wire removed for about $\frac{1}{4}$ of an inch, so as to remain connected only by the film of sulphuret adhering to the remaining gutta percha, an intensity battery could cause this sulphuret to enter into vivid ignition, and fire gunpowder with the utmost ease. The experiment was shewn in the Lecture-room, of firing gunpowder at the end of eight miles of single wire. Mr. Faraday reported that he had seen it fired through 100 miles of covered wire immersed in the canal, by the use of this fuze.

## WEEKLY EVENING MEETING,

Friday, January 27.

Col. Philip J. Yorke, F.R.S., Pres. Chem. Soc., in the Chair.

John Tyndall, Esq., Ph. D., F.R.S.,

Professor of Natural Philosophy, Royal Institution.

### *On the Vibration and Tones produced by the Contact of Bodies having different Temperatures.*

In the year 1805, M. Schwartz, an inspector of one of the smelting works of Saxony, placed a cup-shaped mass of hot silver upon a cold anvil, and was surprised to find that musical tones proceeded from the mass. In the autumn of the same year, Professor Gilbert of Berlin visited the smelting works and repeated the experiment. He observed, that the sounds were accompanied by a quivering of the hot silver, and that when the vibrations ceased, the sound ceased also. Professor Gilbert merely stated the facts, and made no attempt to explain them.

In the year 1829, Mr. Arthur Trevelyan, being engaged in spreading pitch with a hot plastering iron, and once observing that the iron was too hot for his purpose, he laid it slantingly against a block of lead which chanced to be at hand; a shrill note, which he compared to that of the chanter of the small Northumberland pipes, proceeded from the mass, and, on nearer inspection, he observed that the heated iron was in a state of vibration. He was induced by Dr. Reid of Edinburgh to pursue the subject, and the results of his numerous experiments were subsequently printed in the Transactions of the Royal Society of Edinburgh.

On the 1st of April, 1831, these singular sounds and vibrations formed the subject of a Friday Evening Lecture by Professor Faraday, at the Royal Institution. Professor Faraday expanded and further established the explanation of the sounds given by Mr. Trevelyan and Sir John Leslie. He referred them to the tapping of the hot mass against the cold one underneath it, the taps being in many cases sufficiently quick to produce a high musical note. The alternate expansion and contraction of the cold mass at the points where the hot rocker descends upon it, he regarded as the sustaining power of the vibrations. The superiority of lead he ascribed to its great expansibility, combined with its feeble power of conduction, which latter prevented the heat from being quickly diffused through the mass.

Professor J. D. Forbes of Edinburgh was present at this Lecture,

and not feeling satisfied with the explanation, undertook the further examination of the subject; his results are described in a highly ingenious paper communicated to the Royal Society of Edinburgh in 1833. He rejects the explanation supported by Professor Faraday, and refers the vibrations to "a new species of mechanical agency in heat"—a repulsion exercised by the heat itself on passing from a good conductor to a bad one. This conclusion is based upon a number of general laws established by Professor Forbes. If these laws be correct, then indeed a great step has been taken towards a knowledge of the intimate nature of heat itself, and this consideration was the Lecturer's principal stimulus in resuming the examination of the subject.

He had already made some experiments, ignorant that the subject had been further treated by Seebeck, until informed of the fact by Professor Magnus of Berlin. On reading Seebeck's interesting paper, he found that many of the results which it was his intention to seek had been already obtained. The portion of the subject which remained untouched was, however, of sufficient interest to induce him to prosecute his original intention.

The general laws of Professor Forbes were submitted in succession to an experimental examination. The first of these laws affirms that "*the vibrations never take place between substances of the same nature.*" This the Lecturer found to be generally the case when the hot rocker rested upon a *block*, or on the edge of a thick plate of the same metal; but the case was quite altered when a thin plate of metal was used. Thus, a copper rocker laid upon the edge of a penny-piece did not vibrate permanently; but when the coin was beaten out by a hammer, so as to present a thin sharp edge, constant vibrations were obtained. A silver rocker resting on the edge of a half-crown refused to vibrate permanently; but on the edge of a sixpence continuous vibrations were obtained. An iron rocker on the edge of a dinner knife gave continuous vibrations. A flat brass rocker placed upon the points of two common brass pins, and having its handle suitably supported, gave distinct vibrations. In these experiments the plates and pins were fixed in a vice, and it was found that the thinner the plate, within its limits of rigidity, the more certain and striking was the effect. Vibrations were thus obtained with iron on iron, copper on copper, brass on brass, zinc on zinc, silver on silver, tin on tin. The list might be extended, but the cases cited are sufficient to shew that the proposition above cited cannot be regarded as expressing a "general law."

The second general law enunciated by Professor Forbes is, that "*both substances must be metallic.*" This is the law which first attracted the Lecturer's attention. During the progress of a kindred enquiry, he had discovered that certain non-metallic bodies are endowed with powers of conduction far higher than has been hitherto supposed, and the thought occurred to him that such bodies might, by suitable treatment, be made to supply the place of metals in the production of vibrations. This anticipation was realized. Rockers of silver,

copper, and brass, placed upon the natural edge of a prism of rock-crystal, gave distinct tones; on the clean edge of a cube of fluor spar, the tones were still more musical; on a mass of rock-salt the vibrations were very forcible. There is scarcely a substance, metallic or non-metallic, on which vibrations can be obtained with greater ease and certainty than on rock-salt. In most cases a high temperature is necessary to the production of the tones, but in the case of rock-salt the temperature need not exceed that of the blood. A new and singular property is thus found to belong to this already remarkable substance. It is needless to enter into a full statement regarding the various minerals submitted to experiment. Upwards of twenty non-metallic substances had been examined by the Lecturer, and distinct vibrations obtained with every one of them.

The number of exceptions here exhibited far exceeds that of the substances which are mentioned in the paper of Professor Forbes, and is, it was imagined, sufficient to shew that the second general law is untenable.

The third general law states, that "The vibrations take place with an intensity proportional (within certain limits) to the difference of the conducting powers of the metals for heat, the metal having the least conducting power, being necessarily the coldest." The evidence adduced against the first law appears to destroy this one also; for if the intensity of the vibrations be proportional to the difference of the conducting powers, then, where there is no such difference, there ought to be no vibrations. But it has been proved in half a dozen cases, that vibrations occur between different pieces of the same metal. The condition stated by Professor Forbes was, however, reversed. Silver stands at the head of conductors; a strip of the metal was fixed in a vice, and hot rockers of brass, copper, and iron, were successively laid upon its edge: distinct vibrations were obtained with all of them. Vibrations were also obtained with a brass rocker which rested on the edge of a half-sovereign. These and other experiments shew that it is not necessary that the worst conductor should be the cold metal, as affirmed in the third general law above quoted. Among the metals, antimony and bismuth were found perfectly inert by Professor Forbes; the Lecturer however had obtained musical tones from both of these substances.

The superiority of lead as a cold block, Professor Faraday, as already stated, referred to its high expansibility, combined with its deficient conducting power. Against this notion, which he considers to be "an obvious oversight," Professor Forbes contends in an ingenious and apparently unanswerable manner. The vibrations, he urges, depend upon the difference of temperature existing between the rocker and the block; if the latter be a bad conductor and retain the heat at its surface, the tendency is to bring both the surfaces in contact to the same temperature, and thus to stop the vibration instead of exalting it. Further, the greater the quantity of heat transmitted from the rocker to the block during contact, the greater must be the expansion, and hence, if the vibrations be due to this

cause, the effect must be a maximum when the block is the best conductor possible. But Professor Forbes, in this argument, seems to have used the term expansion in two different senses. The expansion which produces the vibration is the sudden upheaval of the point where the hot rocker comes in contact with the cold mass underneath; but the expansion due to good conduction would be an expansion of the general mass. Imagine the conductive power of the block to be infinite, that is to say, that the heat imparted by the rocker is instantly diffused equally throughout the block; then, though the general expansion might be very great, the local expansion at the point of contact would be wanting, and no vibrations would be possible. The inevitable consequence of good conduction is, to cause a sudden abstraction of the heat from the point of contact of the rocker with the substance underneath, and this the Lecturer conceived to be the precise reason why Professor Forbes had failed to obtain vibrations when the cold metal was a good conductor. He made use of *blocks*, and the abstraction of heat from the place of contact by the circumjacent mass of metal, was so sudden as to extinguish the local elevation on which the vibrations depend. In the experiments described by the Lecturer, this abstraction was to a great extent avoided, by reducing the metallic masses to thin laminæ, and thus the very experiments adduced by Professor Forbes against the theory supported by Professor Faraday, appear, when duly considered, to be converted into strong corroborative proofs of the correctness of the views of the philosopher last mentioned.

[J. T.]

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## WEEKLY EVENING MEETING,

Friday, February 3.

Right Hon. Baron Parke, Vice-President, in the Chair.

W. R. Grove, Esq., Q.C., F.R.S.

### *On the Transmission of Electricity by Flame and Gases.*

In the year 1730, Mr. Stephen Grey, a pensioner of the Charter House, was led by pursuing a series of ingenious experiments, to the important discovery that bodies might be divided into two classes, conductors and non-conductors of Electricity. Subsequent discoveries led to the knowledge that different bodies conduct Electricity, not only very differently as to degree, but also differently as to mode, and as to the changes which the bodies themselves experience while conducting electricity. We thence get conduction without apparent change, as by the metals,—conduction dependent upon chemical change, as by Electrolytes; and then again in effects of transmission not usually included under the term conduction, we

get the discharge by carrying or convection, and by disruption, as in the spark.

In the year 1852, Mr. Grove communicated at an Evening Meeting of the Members of the Royal Institution, his researches on the disruptive discharge, shewing by the oxidation and reduction of the terminal surfaces, a state of chemical polarity in the gaseous intervening medium, antecedent to the discharge, the discharge consisting of a subversion of this polarity attended with intense local heat, and a transmission of minute particles of the terminals between which it took place.*

In what may be termed Pneumatic Electricity, or the electrical effects produced on and by gases, there seems some reason to believe that the molecules conduct, or in other words that at indefinitely minute spaces, electricity can pass without the phenomena of disruptive discharge: for instance in the gas battery, either the molecules must conduct, or the gases must by contact with the platinum be brought into a liquid state.

The effects of rarefaction on gases (as by the air-pump) tends to render the disruptive discharge more facile, and to enable electricity of the same degree of intensity to pass across much larger spaces than it would when transmitted across gases in a dense state.

The next enquiry is whether the effect of rarefaction by heat is the same as that by mechanical attenuation; and heated gas was shewn by Mr. Grove to facilitate the disruptive discharge of electricity: so strikingly was this evidenced with flame, that when the flame of a spirit lamp was held near the terminal point of the coil apparatus of Ruhmkorff, (the coatings of a Leyden phial being connected with the secondary coil, and the terminals being separated to a distance far beyond that at which the spark would pass in cold air), the spark darted to and along the margin of the flame, and could be curved or twisted about in any direction, at the will of the experimenter, giving a striking illustration of the crooked form of lightning, and of the probable reason why it does not pass in straight lines, the temperature of the air being different at different points of its passage, and much of this variation of temperature being in all probability occasioned by the mechanical effect on the air of the discharge itself.

No amount of rarefaction has hitherto shewn any thing like *conduction* in gases at ordinary temperatures; but on the other hand flame does give distinct evidence of conduction without disruptive discharge, and an experiment was made demonstrating this.

Is this effect of flame due simply to its consisting of highly heated gas? or is it due to the chemical action taking place throughout the whole structure of the flame?

When closely approximated metals are brought to the point of visible ignition, signs, but very feeble signs of transmission of electricity take place. M. E. Becquerel has recently published some

* Phil. Trans. 1852, p. 87.

very interesting experiments on this subject,* and Mr. Grove not by means of M. E. Becquerel's plan, but by igniting by the voltaic battery two platinum wires placed close to each other in an exhausted receiver, and connecting them with a third voltaic battery, had obtained slight deflections of a delicate galvanometer.

These effects are however far inferior to those shown by flame, and appear to depend more upon the state of the terminals than upon the state of the intervening gas:—thus, until the terminals attain a red heat, no transmission takes place, whatever be the degree of attenuation of the gas; while if the terminals have attained a red heat, the current is much more easily transmitted by rare than by dense gas. Thus alterations in the density of the gas do not appear to affect the trasmission, until a certain definite change has taken place in the state of the terminals. Reasoning from these effects, and bearing in mind the effect of rarefied gas on the disruptive discharge and the quasi-radiation of matter in the phenomena elicited by Moser and others, Mr. Grove inclined to the opinion that the transmission across heated gas differed specifically from that across flame, the former being in some respects analogous to the disruptive, while the latter resembled the electrolytic discharge.

Flame moreover has been observed to conduct better in one direction than another, and the question next arises will flame produce or generate a voltaic current? M. Hankel and M. Buff have published papers shewing, by the use of highly sensitive galvanometers, a current apparently produced by flame, which passes from the upper to the lower part of the flame. M. Buff attributes this current to thermo-electricity—the flame being a conductor and two metals in contact with different parts of it, the thermo-current passes from the hotter to the cooler metal, and hence the result.

Mr. Grove in studying this subject, and without having then read the papers of Hankel and Buff, found the results so varying in ordinary flame that he could come to no satisfactory conclusion; he was then led to think, that as in the flame of the blow-pipe, the direction or line of combustion is more definite than in ordinary flame, he might get more definite results. He experimented with the latter flame, and immediately got very distinct evidence of a current not due to thermo-electricity, as it could be made to conquer both the effect of the thermo-flame-current noticed by Buff, and of any thermo-current excited in the junction of the wires exterior to the flame.

This current which Mr. Grove termed the flame current proper, moves from the root towards the point of the blow-pipe flame—the best points for placing the collecting spirals or plates of platinum being for the one a little above the root or base of the blue cone, and for the other, in the full yellow flame a little beyond the apex of the blue cone.

As the latter metal is much more heated than the former, the thermo-flame-current is opposed to, and though it by no means destroys, it tends to weaken the effect of the flame current proper;

* Annales de Chimie, Nov. 1853.

if then this metal can be adventitiously cooled, we should have the two currents co-operating, instead of conflicting; and so experiment proved, for by using a capsule of platinum filled with water in the full flame, and a coil or sheet of platinum foil at the base, a very marked current resulted. By arranging in a row of jets worked by a large bellows a sheet of platinum foil placed just over the roots of the flames, and a trough of platinum foil filled with water just beyond the points of the blue cones, the large galvanometer of the Institution was deflected to 30° or 40°, so as to be easily visible to the audience; the deflection being in the reverse direction upon reversing the connections respectively with the plate and trough. The same apparatus will also readily decompose iodide of potassium; iodine being evolved at the platinum point in connection with the trough.

There was another apparatus on the table for arranging the flame battery as an intensity series. The direction of the current is from the points in the flame where combustion commences, to those where it concludes; it appears to be transmitted by a chain of chemical action taking place between these. Though speaking with some reserve on the theory of the phenomenon, Mr. Grove could at present see no objection to its being regarded as a current produced by chemical action; the platinum at the commencement of action representing the zinc which burns or combines with oxygen; that at the conclusion, representing the platinum, or the points where chemical action concludes, and a tendency to reduction or deoxidation is manifested. The distinction being that the generative chemical action, instead of taking place, as in the ordinary battery only at the zinc surface, and being simply transmitted by the electrolyte, takes place throughout the intervening section of flame; and thus, within certain limits, the intensity of the electricity increases with the distance of the plates, instead of decreasing as in the ordinary battery. [W. R. G.]

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## GENERAL MONTHLY MEETING,

Monday, February 6, 1854.

WILLIAM POLE, ESQ., M.A., F.R.S., Treasurer and Vice-President, in the Chair.

Archibald Boyd, Esq.
John Hall Gladstone, Esq., Ph. D., F.R.S.
William Scurfield Grey, Esq.
Thomas Haig, Esq.
Matthew Noble, Esq.
John Percy, M.D., F.R.S.
Samuel Petrie, Esq.
Michael Wills, Esq.

were duly *elected* Members of the Royal Institution.

The following PRESENTS were announced; and the thanks of the Members returned for the same: —

FROM

*Actuaries, Institute of* — The Assurance Magazine, No. 14. 1854. 8vo.
*Agricultural Society, Royal* — Journal, Vol. XIV. Part 2. 8vo. 1853.
*American Academy of Arts and Sciences* — Memoirs, New Series, Vol. V. Part 1. Cambridge, U. S. 1853.
*Art-Union of London* — Seventeenth Annual Report. 8vo. 1853.
Almanac for 1854.
*Asiatic Society of Bengal* — Journal, No. 236. 8vo. 1853.
*Astronomical Society, Royal* — Monthly Notices, Vol. XIV. Nos. 1, 2. 8vo. 1853.
*Barnard, George, Esq. (the Author)* — Handbook of Foliage and Foreground Drawing. 16mo. 1853.
*Basel, Naturforschende Gesellschaft* — Bericht über die Verhandlungen, vom Aug. 1850 bis Juni 1852. 8vo. Basel, 1852.
*Bell, Jacob, Esq. (the Editor)* — Pharmaceutical Journal, Jan. and Feb. 1854.
*Bodichon, Dr. (the Author)* — De l'Humanité Génèse. 8vo. Alger, 1854.
Projet d'un Exploration d'Alger à Tombouctou par le Sahara. 8vo. Paris, 1849.
*Bombay Branch of the Royal Asiatic Society* — Journal, No. 1—18. 8vo. Bombay, 1841-53.
*Bosanquet, J. W. (the Author)* — The Fall of Nineveh and the Reign of Sennacherib, chronologically considered with a view to the Readjustment of Sacred and Profane Chronology. 8vo. 1853.
*Boosey, Messrs. (the Publishers)* — The Musical World for Jan. 1854. 4to.
*British Architects, Royal Institute of* — Proceedings, Dec. 1853 and Jan. 1854.
*Chemical Society* — Quarterly Journal, No. 24. 8vo. 1854.
*Cheshire, Edward, Esq. Assist. Sec. Statist. Soc. (the Author)* — Results of the Census of Great Britain in 1851; with a Description of the Machinery and Processes employed to obtain the Returns. 8vo. 1853.
*Civil Engineers, Institution of* — Proceedings, Dec. 1853 and Jan. 1854. 8vo.
*De Brock, M., Ministre des Finances de Russie* — Annales de l'Observatoire Physique Central de Russie, &c., par A. Kupffer. Année 1850. 2 vols. 4to. St. Pétersbourg, 1853.
Compte-Rendu Annuel du Directeur de l'Observatoire Physique Central de Russie pour l'Année 1852. 4to. 1853.
*De la Rue, Warren, F.R.S.. M.R.I.* — Saturn as seen with a Newtonian Equatoreal of 13 inches aperture, Nov. 1852. (Warren De la Rue, delt.) Engraving. 1853.
*Demidoff, the Prince* — Observations Météorologiques faites à Nijné Taguilsk (Monts-Oural), Gouvernement de Perm. Années 1850-1. 8vo. Paris, 1852.
*East India Company, the Hon.* — Magnetical and Meteorological Observations made at Bombay in 1849. 4to. 1852.
*Editors* — The Athenæum for Dec. 1853, and Jan. 1854. 4to.
The Medical Circular for Dec. 1853, and Jan. and Feb. 1854. 4to.
The Practical Mechanic's Journal for Jan. and Feb. 1854. 4to.
The Common Law and Equity Reports. Vol. 1. Parts 7, 8. 8vo. 1853-4.
The Journal of Industrial and Social Progress. No. 1. Jan. 1854. 8vo.
The Journal of Gas-Lighting, Dec. 1853, and Jan. 1854. 4to.
*Faraday, Professor, D.C.L., F.R.S.*
Kaiserliche Akademie der Wissenschaften, Wien: —
*Philosophisch-Historische Classe* — Sitzungsberichte. Band X. Heft 4. 8vo. 1853.
Archiv für Kunde Oesterreichischer Geschichtsquellen. Band X. Heft 1. 8vo. 1853.
Fontes Rerum Austriacarum. Zweite Abtheilung. Band VII. 8vo. 1853.
Monumenta Habsburgica. Zweite Abtheilung. Band I. 8vo. 1853.
*Mathematisch-Naturwissenschaftliche Classe:* — Denkschriften. Band IV. Lieferung 1. Band V. Lieferung 2. 4to. 1853.
Sitzungsberichte. Band X. Hefte 4 und 5. 8vo. 1853.

*Faraday, Professor, D.C.L., F.R.S.—(continued).*
Monatsberichte der Königl. Preuss. Akademie, Sept.—Dec. 1853. 8vo.
*Franklin Institute of Pennsylvania*—Journal, Vol. XXVI. Nos. 4—6. Vol. XXVII. No. 1. 8vo. 1853—4.
*Graham, George, Esq., Registrar-General*—Census of Great Britain, 1851: Religious Worship—England and Wales. Report and Tables. 8vo. 1853.
*Hamilton, Edward, M.D., F.L.S., M.R.I. (the Author)*—Flora Homœopathica. Vol. II. 8vo. 1853.
*Hellyer, W. V., Esq., M.R.I.*—Remarks by Col. Chesney, D.C.L. F.R.S., on the Tubular Life-boat invented by H. Richardson, Esq. 16mo. 1853.
*Hesketh, R., Esq. (the Author)*—"Shall the New Street between the Eastern and Western Parts of the Metropolis be Straight or Crooked?" 8vo. 1854.
*Horticultural Society of London*—Journal, Vol. IX. Part 1. 8vo. 1854.
*Irish Academy, Royal*—Proceedings, Vol. II. and Vol. V. Part 3. 8vo. 1840—53.
*London, University of*—The London University Calendar, 1854. 12mo. 1854.
*Lovell, E. B., Esq., M.R.I. (the Editor)*—Monthly Digest, Dec. 1853, Jan. 1854.
*Maury, M.F., Lieut. U.S.N. (Superintendent of the National Observatory, Washington)*—Official Report of the United States Expedition to explore the Dead Sea and the River Jordan. By Lieut. W. F. Lynch, U.S.N. 4to. Baltimore, U.S. 1852.
Maury's Sailing Directions. Fifth Edition. 4to. Washington, 1853.
*Novello, Messrs. (the Publishers)*—The Musical Times, Jan. and Feb. 1854.
*Parker, J. W., Esq.*—Poetical Works of John Dryden. Edited by R. Bell. Vol. I. 16mo. 1854.
*Parkyns, Mansfield, Esq., M.R.I. (the Author)*—Life in Abyssinia; being Notes collected during Three years' Residence and Travels in that country. 2 Vols. 8vo. 1853.
*Petermann, A. Esq. (the Author)*—Royal Geographical Kalendar for 1854.
*Photographic Society*—Journal, No. 12. 8vo. 1853.
*Pollock, F., Esq., M.R.I. (the Translator)*—The Divine Comedy of Dante. With Illustrations by G. Scharf. 8vo. 1854.
*Royal Society of London*—Proceedings, No. 99. 8vo. 1853.
*Sabine, Col. Edward, R.A., V. P. R. S. (the Author)*—On the Influence of the Moon on Magnetic Declination, &c. (Phil. Trans.) 4to. 1853.
*Shelford, Leonard, Esq. (the Author)*—The Law of Copyholds, and the Copyhold Acts; with Notes. 12mo. 1853.
*Smith, John, Esq. Mus. D. (the Author)*—A Treatise on the Theory and Practice of Music. 4to. 1853.
*Society of Arts*—Journal, Nos. 55—63. 8vo. 1853—4.
*Statistical Society*—Journal, Vol. XVI. Part 4. 8vo. 1853.
*St. Petérsbourg, l'Académie Impériale des Sciences de*—Mémoires, Sixième Série. Sciences Mathématiques. Tome V. Livraisons 5 et 6. 4to. 1853.
*Thimm, Mr. F. (the Publisher)*—Deutsches Athenäum, Jan. 1854.
*Tyndall, Professor, J., Ph. D., F.R.S.*—Untersuchungen über die Heizkraft der wichtigeren Brennstoffe des Preussischen Staates, von Dr. P. W. Brix. 4to. Berlin, 1853.
*Twining, Thomas, Jun., Esq., M.R.I. (the Author)*—Letters on the Condition of the Working Classes of Nassau. 8vo. 1853.
*Ward, N. B., Esq., F.R.S., F.L.S. (the Author)*—On the Growth of Plants in Closely-Glazed Cases. 2nd Edition. 12mo. 1852.
*Williams, John, Esq. (the Author)*—Chinese Numismatics. 8vo. 1853.

## WEEKLY EVENING MEETING,

Friday, February 10.

Right Hon. BARON PARKE, Vice-President, in the Chair.

PROFESSOR OWEN, F.R.S.

*On the Structure and Homologies of Teeth.*

THE Lecturer commenced by observing that, although the teeth were among the least vitalised of animal parts, and commonly possessed no power of repairing fracture or decay, they presented many phenomena of anatomical, physiological, and homological interest, a selection from which he proposed to offer as the subject of the evening's discourse.

Any hard body attached to the walls and projecting into the cavity of the mouth, where it is exposed to view when the mouth is open, is called a *tooth:* but the parts properly so called, are those which consist of a gelatinous basis, hardened by earthy salts, in which the phosphate of lime predominates. Such teeth are peculiar to the Vertebrate Classes. In them they present manifold varieties as to number, size, form, structure, position, and mode of attachment, but are principally adapted for seizing, tearing, dividing, pounding, or grinding the food; in some species they are modified to serve as formidable weapons of offence and defence; in others as aids in locomotion, means of anchorage, instruments for uprooting or cutting down trees, or for transport and working of building materials; they are characteristic of age and sex; and in man they have secondary relations subservient to beauty, and to speech.

Teeth are always intimately related to the food and habits of the animal, and are therefore highly interesting to the physiologist: they form for the same reason important guides to the naturalist in the classification of animals; and their value, as zoological characters, is enhanced by the facility with which, from their position, they can be examined in living or recent animals; whilst the durability of their tissues renders them not less available to the palæontologist in the determination of the nature and affinities of extinct species, of whose organisation they are often the sole remains discoverable in the deposits of former periods of the earth's history.

Teeth are not of an uniform tissue or substance like bone: that which forms the body of the tooth is called "dentine;" the tissue which forms the outer crust is called "cement;" and in most Vertebrata a third substance is situated between the dentine and cement, called "enamel." The characteristics of these three

primary tissues of a tooth were briefly defined: they differ in hardness, the cement being least dense, the enamel most.

The tubular structure of the dentine relates to the disposition of the hard material so as best to resist pressure, and to the circulation of plasma, transuded from the pulp through the dentine, so as to maintain a certain, though languid, vitality of the tissue.

Some secondary modifications of the chief tissue of teeth were noticed under the names of osteo-dentine, vaso-dentine, vitro-dentine, dendro-dentine and labyrintho-dentine: the latter highly complex and beautiful modification, being due rather to a modification of disposition, than of composition of the dentine itself. The singular labyrinthic interblending of the dentine and cement, reaches its maximum of complexity in the teeth of some gigantic extinct batrachian Reptiles, from the Triassic formations, called from their distinct peculiarities "Labyrinthodonts."

The chief varieties in the form of the teeth in Fishes were then enumerated, and more especially illustrated in the predatory Pike, the vegetarian Carp, the shell-crushing Myliobates and the coral-browzing Scarus. The elastic attachment of the teeth of the Lophius, and the mode of growth and succession of the Shark's numerous teeth were explained.

From the class of Reptiles examples of dental structure were selected; from the Serpent-tribes, in relation to the poison-apparatus, and from the Crocodile, in respect of the constant succession and displacement of the teeth. The structure of the teeth of the extinct Iguanodon and Megalosaurus was also noticed.

The Mammalian class might be divided in regard to the succession of the teeth, into two groups—the *Monophyodonts*, or those that generate but one set of teeth, and the *Diphyodonts*, or those that generate two sets of teeth.

The Monophyodonts include the Cetacea and the *Bruta* (*Edentata* of Cuvier); all the other Orders are Diphyodonts.

The teeth of the Mammalia, especially the Diphyodonts, have usually so much more definite and complex a form than those of fishes and reptiles, that three parts are recognised in them: *viz.* the "fang," the "neck," and the "crown." The fang or root (*radix*) is the inserted part; the crown (*corona*) the exposed part; and the constriction which divides these is called the neck (*cervix*). The term "fang" is properly given only to the implanted part of a tooth of restricted growth, which fang gradually tapers to its extremity; those teeth which grow uninterruptedly have not their exposed part separated by a neck from their implanted part, and this generally maintains to its extremity the same shape and size as the exposed crown.

It is peculiar to the class Mammalia to have teeth implanted in sockets by two or more fangs; but this can only happen to teeth of limited growth, and generally characterises the molars and

premolars; perpetually growing teeth require the base to be kept simple and widely excavated for the persistent pulp. In no mammiferous animal does anchylosis of the tooth with the jaw constitute a normal mode of attachment. Each tooth has its particular socket, to which it firmly adheres by the close co-adaptation of their opposed surfaces, and by the firm adhesion of the alveolar periosteum to the organised cement which invests the fang or fangs of the tooth.

True teeth implanted in sockets are confined, in the Mammalian class, to the maxillary, premaxillary, and mandibular, or lower maxillary bones, and form a single row in each. They may project only from the premaxillary bones, as in the Narwhal, or only from the lower maxillary bone, as in Ziphius; or be apparent only in the lower maxillary bone, as in the Cachalot; or be limited to the superior and inferior maxillaries, and not present in the premaxillaries, as in the true Ruminants and most Bruta.

The teeth of the Mammalia usually consist of hard unvascular dentine, defended at the crown by an investment of enamel, and everywhere surrounded by a coat of cement. The coronal cement is of extreme tenuity in Man, Quadrumana, and terrestrial Carnivora; it is thicker in the Herbivora, especially in the complex grinders of the Elephant; and is thickest in the teeth of the Sloths, Megatherioids, Dugong, Walrus, and Cachalot. Vertical folds of enamel and cement penetrate the crown of the tooth in the Ruminants, and in most Rodents and Pachyderms, characterising by their various forms the genera of the last two orders; but these folds never converge from equidistant points of the circumference of the crown towards its centre. The teeth of the quadrupeds of the order *Bruta* (*Edentata*, Cuv.) have no true enamel; this is absent likewise in the molars of the Dugong and the Cachalot. The tusks of the Narwhal, Walrus, Dinotherium, Mastodon, and Elephant, consist of modified dentine, which, in the last two great proboscidian animals is properly called "ivory," and is covered by cement.

The Dolphins and Armadillos present little variety in the shape of teeth in the same animal, the teeth are often very numerous; and this sameness of form is characteristic of most of the monophyodonts.

In almost all the other Mammalia, particular teeth have special forms for special uses: thus, the front teeth, from being commonly adapted to effect the first coarse division of the food, have been called cutters or *incisors*; and the back teeth, which complete its comminution, grinders or *molars*; large conical teeth, situated behind the incisors, and adapted by being nearer the insertion of the biting muscles, to act with greater force, are called holders, tearers, laniaries, or more commonly *canine* teeth, from being well developed in the dog and other Carnivora, although they are given, likewise, to many vegetable feeders for defence or combat: *e. g.* Musk-deer.

Molar teeth, which are adapted for mastication, have either tuberculate, or transversely ridged, or flat summits, and usually are either surrounded by a ridge of enamel, or are traversed by similar ridges arranged in various patterns. Certain molars in the Dugong, the Mylodon, and the Zeuglodon, are so deeply indented laterally by opposite longitudinal grooves, as to appear, when abraded, to be composed of two cylindrical teeth cemented together, and the transverse section of the crown is bilobed. The teeth of the *Glyptodon* were fluted by two analogous grooves on each side. The large molars of the Capybara and Elephant have the crown cleft into a numerous series of compressed transverse plates, cemented together side by side.

The modifications of the crown of the molar teeth are those that are most intimately related to the kind of food of the animal possessing them. Illustrations were given of the chief of these modifications in the purely Carnivorous mammals, where the molars are simple, trenchant, and play upon each other like scissor-blades: in the mixed feeding species where the working surface of the molars is flattened or tuberculated: in the insectivorous species where it is bristled with sharp points: and in the purely herbivorous kinds, where the broad grinding surfaces of the teeth are complicated by folds and ridges of the enamel entering the substance of the tooth: the most complex forms being presented by the Elephants.

Teeth of each of the kind above determined, and arbitrarily named "incisors," "canines," "molars," have received other special names, in regard to certain peculiarities of form or other property; and the ablest comparative anatomists have been led astray in determining their homologies when they have suffered themselves to be guided exclusively by morphological characters. The small anterior grinding teeth in the human subject have been called "bicuspids." The penultimate upper tooth and the last lower tooth in the Lion are termed, from their peculiar form, "sectorials," or "carnassial teeth," "molaires carnassières" of Cuvier. Teeth of an elongated conical form, projecting considerably beyond the rest, and of uninterrupted growth, are called "tusks;" such are the incisors of the Elephant and Dugong, and the canines of the Boar and Walrus: the long and large incisors of the Rodents have been termed, from the shape and structure of their cutting edge, scalpriform or chisel-teeth, "*dentes scalprarii.*" The inferior incisors of the flying Lemurs (*Galeopithecus*) have the crown deeply notched like a comb, and are termed "*dentes pectinati.*" The canines of the Baboons are deeply grooved in front, like the poison fangs, "*dentes canaliculati,*" of some serpents. The compressed conical crowns of the molar teeth of the small clawed seals, *Stenorhynchus*, are divided either like a trident into three sharp points, or like a saw, into four or five points; the molars of the great extinct *Zeuglodon* had a similar form; such

teeth have been called *dentes serrati.* But the philosophical course of the knowledge of nature tends to explode needless terms of art, invented for unimportant varieties, and to establish and fix the meaning of those words that are the signs of determinate species of things.

The Cuviers divided the molar series of teeth, according to their form, into three kinds: "false molars," "carnassials," and "tubercular molars;" and, in giving the generic characters of Mammalia, based the dental formulæ on this system: thus the genus *Felis* is characterised as having "fausses molaires $\frac{2-2}{2-2}$, carnassières $\frac{1-1}{1-1}$, tuberculeuses $\frac{1-1}{0-0}$; $=\frac{8}{6}$."

In a diagram of the leading modifications of Diphyodont dentition, an uninterrupted line marked "Cuvier" was made to intersect the teeth in each jaw of the Carnivora, called by that great anatomist, "carnassières;" those anterior to them being the teeth which he called "fausses molaires;" those behind being the "tuberculeuses." Most zoologists, both at home and abroad, have adopted the Cuvierian system of formulising the molar teeth. Prof. De Blainville, however, abandoned that classification of the molar series, without assigning his objections to it; and proposed another, in which he divides the series into "avant-molaires," "principales," and "arrière-molaires;" he exemplifies this division by the human dentition, in which the five grinders on each side of both jaws are formulised as "two avant-molaires, one principale, and two arrière-molaires." The teeth regarded by De Blainville as the homologues of these, were indicated in the diagram above referred to by a dotted line intersecting the "dent principale" in each species.

Truly homologous teeth are determined, like other parts, by their relative position, by their connections, and by their development. The teeth of one side of the jaw repeat, are answerable to, or are *homotypes*, of the teeth on the other side; and those in the upper jaw usually correspond, in like manner, to those in the under jaw.

Those teeth which are implanted in the premaxillary bones, and in the corresponding part of the lower jaw, are called "incisors," whatever be their shape or size. The tooth in the maxillary bone, which is situated at, or near to, the suture with the premaxillary, is the "canine," as is also that tooth in the lower jaw which, in opposing it, passes *in front of its crown* when the mouth is closed. The first-formed incisors and canines are deciduous; they are succeeded and displaced vertically by the permanent incisors and canines. With regard to the other teeth, their true nature, and homologies, about which the difference of opinion has chiefly prevailed amongst anatomists, are determinable not by shape or size, or by relative position to the

zygoma, but by developmental characters exclusively. The first set are the "deciduous molars;" the teeth which displace and succeed them vertically are the "premolars;" the more posterior teeth, which are not displaced by vertical successors, but succeed each other horizontally, are the "molars" properly so called.

The phenomena of the development and succession of the teeth were then explained and illustrated in examples of Carnivorous, Herbivorous, and mixed-feeding species of Diphyodont Mammalia.

Genus *Felis*.—In the Cat, the deciduous incisors begin to appear between two and three weeks old; the canines next, and then the molars follow, the whole being in place before the sixth week. After the seventh month they begin to fall in the same order; but the lower sectorial molar and the tubercular tooth above, appear before the deciduous molars are shed; they do not push out any predecessors, and have no successors; they are, therefore, true molars. The first deciduous molar in the upper jaw is a very small and simple one-fanged tooth; it is succeeded by the corresponding tooth of the permanent series, which answers to the second premolar of the hyæna and dog. The second deciduous molar is the sectorial tooth; its blade is trilobate, but both the anterior and posterior smaller lobes are notched, and the internal tubercle, which is relatively larger than in the permanent sectorial, is continued from the base of the middle lobe, as in the deciduous sectorial of the dog and hyæna; it thus typifies the form of the upper sectorial, which is retained in the permanent dentition of several Viverrine and Musteline species. The third or internal fang of the deciduous sectorial is continued from the inner tubercle, and is opposite the interspace of the two outer fangs. The Musteline type is further adhered to by the young Feline in the large proportional size of its deciduous tubercular tooth. In the lower jaw, the first milk-molar is succeeded by a tooth which answers to the third lower premolar in the dog and civet. The deciduous sectorial, which is succeeded by the premolar, answering to the fourth in the dog, has a smaller proportional anterior lobe, and a larger posterior talon, which is usually notched; thereby approaching the form of the permanent lower sectorial tooth in the *Mustelidæ*. The last tooth which is functionally analogous to the carnassial above, is the first of the true molar series, and is the homotype of the little tubercular tooth above.

The true nature of the dentition of the Lion and other Felines, as determined by the above phenomena of development is:— $i.\ \frac{3-3}{3-3},\ c.\ \frac{1-1}{1-1},\ p.\ \frac{3-3}{2-2},\ m.\ \frac{1-1}{1-1}$: signifying that there are 3 incisors, 1 canine, 3 premolars and 1 molar, on each side of the upper jaw, and the same, with the exception of a small premolar, on each side of the lower jaw. The teeth, which are the seat of

the sectorial or carnassial modifications, are not homologous or homotypal in the two jaws.

In the genus *Ursus* the dentition was, in like manner, shown to be:— $i.\ \frac{3-3}{3-3},\ c.\ \frac{1-1}{1-1},\ p.\ \frac{4-4}{4-4},\ m.\ \frac{2-2}{3-3} = 42.$

In the Hog, four deciduous molars are succeeded by four premolars, vertically; and three molars are developed in horizontal succession behind these, the dental formula being:— $i.\ \frac{3-3}{3-3},\ c.\ \frac{1-1}{1-1},\ p.\ \frac{4-4}{4-4},\ m.\ \frac{3-3}{3-3} = 44.$

This number of teeth is never surpassed in the Diphyodont series; and the Lecturer regarded it as the typical dentition. It is, however, rarely maintained in existing species, but appears to have been much more common in extinct Mammalia, especially those from the most ancient tertiary epochs; illustrations of which were given in the *Hyænodon*, and *Hyopotamus*, and examples cited in the extinct genera *Chæropotamus*, *Anthracotherium*, *Hyracotherium*, *Oplotherium*. *Merycopotamus*, *Hippohyus*, *Anoplotherium*, *Palæotherium* and *Faloplotherium*. In the three latter genera, Professor Owen had determined the nature of the molar series to be the same as in the Hog, by specimens shewing the deciduous dentition.

In the hoofed quadrupeds with toes in uneven number (*Perissodactyla*), whose premolars, for the most part, repeat both the form and the complex structure of the true molars, such premolars are distinguished by the same character of development as those of the *Artiodactyla*, or Ungulates with toes in even number; although here the premolars are distinguished also by modifications of size and shape.

In most of the South American Quadrumana, the number of teeth as contrasted with the Monkeys of Africa and Asia, is increased to thirty-six, by an addition of one tooth to the molar series on each side of both jaws. It might be concluded *à priori*, that as three is the typical number of true molars in the placental Mammalia with two sets of teeth, the additional tooth in the New-World Monkeys would be a premolar, and form one step to the resumption of the normal number (four) of that kind of teeth. The proof of the accuracy of this inference was given by the state of the dentition in the young of the Howler-Monkey (*Mycetes*) in which a diagram was exhibited of a dissection of the jaws, exposing the germs of the permanent teeth: the crown of a premolar being found above the *third* milk-molar in place, as well as above the *second* and *first*. As regards number, therefore, the molar series, in Mycetes, is intermediate between that of the bear, *Ursus*, and *Felis*; the little premolar *p. i.* in *Ursus*, tells plainly enough which of the four is wanting to complete the typical number in the South American Monkey, and which is the additional premolar

distinguishing its dental formula from that of the Old World monkeys and man.

With regard to the Human Dentition, the discovery, by the great poet Göethe, of the limits of the premaxillary bone in man, leads to the determination of the incisors, which are reduced, as in Apes and Monkeys, to two on each side of both jaws; the contiguous tooth shows by its shape, as well as position, that it is the canine; and the characters of size and shape have also served to divide the remaining five teeth in each lateral series into two bicuspids and three molars. In this instance, as in the dentition of the bear, the secondary characters conform with the essential ones. But since we have seen of how little value shape or size are, in the order Carnivora, in the determination of the exact homologies of the teeth, it is satisfactory to know that the more constant and important character of development gives the requisite certitude as to the nature of the so-called bicuspids in the human subject. The condition of the teeth was shown in the jaws of a child of about six years of age. The two incisors on each side are followed by a canine, and this by three teeth having crowns resembling those of the three molar teeth of the adult. In fact, the last of the three is the first of the permanent molars; it has pushed through the gum, like the two molars which are in advance of it, without displacing any previous tooth, and the substance of the jaw contains no germ of any tooth destined to displace it: it is therefore, by this character of its development, a true molar, and the germs of the permanent teeth, which are exposed in the substance of the jaw between the diverging fangs of the two anterior molars, prove them to be temporary, destined to be replaced, and prove also that the teeth about to displace them are premolars. According, therefore, to the rule previously laid down, we count the permanent molar in place, the first of its series, and the adjoining premolar as the last of its series, and consequently the fourth of the typical dentition; the next premolar in advance being the penultimate or third of the typical series.

We are thus enabled, with the same scientific certainty as that whereby we recognise in the middle toe of the foot the homologue of that great digit which forms the whole foot, and is encased by the hoof in the horse, to point to the second bicuspid in the upper jaw, and to the first molar in the lower jaw of man, as the homologues of the great carnassial teeth of the lion and tiger. We also conclude that the teeth which are wanting in man to complete the typical molar series, are the first and second premolars, the homologues of those which were marked in the diagram of the dentition of the bear. The characteristic shortening of the maxillary bones required this diminution of the number of their teeth, as well as of their size, and of the canines more especially; and the still greater curtailment of the premaxillary bone is attended with

a diminished number and an altered position of the incisors. One sees, indeed, in the carnivorous series, that a corresponding decrease in the number of the premolars is concomitant with the shortening of the jaws. Already in the *Mustelidæ*, the first premolar below is abrogated; in *Felis* also above, with the further loss of the second premolar in the lower jaw; the true molars being correspondingly reduced in these strictly flesh-eating animals, but taken away from the back part of their series.

If we were desirous of further testing the soundness of the foregoing conclusions as to the nature of the teeth absent in the reduced dental formula of man, we ought to trace the mode in which the type is progressively resumed in descending from man through the order most nearly allied to our own.

Through a considerable part of the Quadrumanous series, *e. g.* in all the Old World genera above the Lemurs, the same number and kinds of teeth are present as in man; the first deviation being the disproportionate size of the canines and the concomitant break or "diastema" in the dental series for the reception of their crowns when the mouth is shut. This is manifested in both the Chimpanzees and Orangs, together with a sexual difference in the proportions of the canine teeth. Then comes the added premolar in the New-World Monkeys, and the further additions in lower quadrupeds, until in the Hog genus we see the old primitive type of Diphyodont dentition resumed or retained.

With regard to the application of the above principles and characters to other or newly discovered species:—When the premolars and the molars are below their typical number, the absent teeth are missing from the fore-part of the premolar series and from the back part of the molar series. The most constant teeth are the fourth premolar and the first true molar; and, these being known by their order and mode of development, the homologies of the remaining molars and premolars are determined by counting the molars *from before backwards*, *e. g.* "one," "two," "three;" and the premolars *from behind forwards*, "four," "three," "two," "one." The incisors are counted from the median line, commonly the foremost part of both upper and lower jaws, outwards and backwards. The first incisor of the right side is the homotype, transversely, of the contiguous incisor of the left side in the same jaw, and, vertically, if its opposing tooth in the opposite jaw; and so with regard to the canines, premolars, and molars; just as the right arm is the homotype of the left arm in its own segment, and also of the right leg of a succeeding segment. It suffices, therefore to reckon and name the teeth of one side of either jaw in a species with the typical number and kinds of teeth; *e. g.* the first, second, and third incisors,—the first, second, third, and fourth premolars,—the first, second, and third molars; and of one side of both jaws in any case.

The homologous teeth being thus determinable, they may be severally signified by a symbol as well as by a name. The incisors, *e. g.*, by their initial letter *i.*, and individually by an added number, *i.* 1, *i.* 2, and *i.* 3; the canines by the letter *c.*; the premolars by the letter *p.*; and the molars by the letter *m.*; these also being differentiated by added numerals. Thus, the number of these teeth, on each side of both jaws, in any given species, Man *e. g.*, may be expressed by the following brief formula:— $i.\ \frac{2-2}{2-2},\ c.\ \frac{1-1}{1-1},\ p.\ \frac{2-2}{2-2},\ m.\ \frac{3-3}{3-3} = 32$; and the homologies of the individual teeth, in relation to the typical formula, may be signified by *i.* 1., *i.* 2.; *c.*; *p.* 3., *p.* 4.; *m.* 1., *m.* 2., *m.* 3.: the suppressed teeth being *i.* 3., *p.* 1., and *p.* 2.

These symbols are so plain and simple as to form no obstacle to the ready comprehension of the facts explained by means of them. Were those facts described in the ordinary way, by means of the verbal phrases or definitions of the teeth; as for example, in Man, "the second deciduous molar, representing the fourth deciduous molar in the typical dentition," instead of *d.* 4, and so on, the descriptions of the manifold modifications of the teeth and of dental development must continue to occupy much unnecessary space, and levy such a tax upon the attention and memory, as would inevitably tend to enfeeble the judgment and impair the power of seizing and appreciating the results of the comparison.

Each year's experience had strengthened the Lecturer's conviction that the rapid and successful progress of the knowledge of animal structures, and of the generalizations deducible therefrom, would be mainly influenced by the determination of the homology of parts and organs, and by the concomitant power of condensing the propositions relating to them, and attaching to them signs or symbols, equivalent to their single substantive names. In the Lecturer's work on the "Archetype of the Skeleton," he had denoted most of the bones by simple numerals; the symbols of the teeth are fewer in number, are easily understood and remembered; and, if generally adopted, might take the place of names: they would, then, render unnecessary the endless repetition of the verbal definition of the part, harmonise conflicting synonyms, serve as a universal language, and at the same time express the expositor's meaning in the fewest and clearest terms. The Entomologist had long found the advantage of such signs as ♂ and ♀, in reference to the sexes of Insects and the like; and the Anatomist would find it to his advantage to avail himself of this powerful instrument of thought, instruction, and discovery, from which the Chemist, the Astronomer, and the Geometrician have obtained such important results. [R. O.]

[FOR THE USE OF MEMBERS.]

# Royal Institution of Great Britain.

1854.

## WEEKLY EVENING MEETING,

Friday, February 17.

Right Hon. BARON PARKE, Vice-President, in the Chair.

JOHN CONOLLY, M.D., D.C.L.

*On the Characters of Insanity.*

HOWEVER various the forms of Insanity appear to the inexperienced visitor of an Asylum, it is found that in every case there is either Mania or Melancholia, only varying in degree and manifestation. There is either excitement or depression, more or less continued, and more or less influencing the mental faculties. It may perhaps be strictly said that all the forms of mental disorder are dependent on one of three states of the Nervous System,—a state of increased, or a state of diminished, or a state of unequal excitement of that system. There is almost always accompanying disorder of some of the bodily functions; of the circulation, which is so implicated with the nervous system; and of digestion and assimilation; and of the function by which animal heat is preserved and regulated. Sleep is always imperfect. The improvement of the bodily health usually precedes mental recovery. Recent, or chronic mania, or recent or chronic melancholia, may appear in paroxysms, or may persist without intervals of mitigation. They may appear alternately. The delusions usually accompanying the malady may appear in the paroxysms only, or remain permanently even in the intervals. All other forms of Insanity appear to be mere varieties, or complications, or results.

Mania is usually ushered in by a change in the ordinary habits of life. Impatience in business, irritability, fits of silent thought, inattention to appearances, disregard of hours,—characterise incipient disorder. Irregularity as to diet, and restless nights, and a general alteration of countenance and manner are observed. The face and figure undergo unfavourable change; the manners become morose; innumerable letters are written, chiefly on public affairs. The patient thinks he is accused of crimes, and prepares to resist going to prison; or he escapes, and wanders over the country; or rushes into the streets and declaims loudly, or commits actions of violence. In Melancholia the patient often thinks himself reduced to poverty, and without hope in this world or the next; and expresses an intention to destroy himself, and attempts to do so. Women are among the most frequent subjects of melancholia; they become in-

dolent, apathetic, silent, indifferent to all around them; they accuse themselves of unpardonable sins, and refuse all religious consolation, This state often arises from disappointment of the affections, sometimes from some sudden mental shock, and not unfrequently from mere debility. The disposition to suicide is manifested with an ingenuity and perseverance which demand incessant watching. But all these miserable symptoms of malady are often recovered from.

In the above forms of mental disorder it is found, in a large proportion of instances, that there is a constitutional disposition in the patient disposing him to such attacks. Another, and a very peculiar and serious form often arises without any known predisposition; and this form of malady seems to be becoming more common than formerly. Forty years ago, it was not known, or not described; and except among physicians familiar with the insane, its characters are scarcely yet distinctly recognised. It appears in men of all classes of life, but seldom in women. Its causes are most commonly to be found in anxieties, over-exertion in depressing circumstances, reverses, and shocks. In some instances intemperance, and in others violent injuries of the head, seem to induce it. Its commencement is marked by a more singular disregard of ordinary circumstances and of prudential habits than any other form of insanity. Business is neglected, new pursuits are adopted, expense is needlessly incurred in the gratification of extravagant fancies. The patient considers himself on the eve of possessing great wealth and high rank. He boasts of his accomplishments, and speaks of vast designs which he is to accomplish. His temper becomes capricious; contradiction or doubt exasperate him; and his occasional violence alarms his family. The physician finds these mental peculiarities associated with a peculiar lingering in the speech, and a very slight alteration in the mode of walking: but his patient is in the highest spirits, and acknowledges no consciousness of illness: he is pleased, however, to see his physician; pleased to go from home; pleased with an asylum if placed in one; and satisfied for a time with every thing. Now and then paroxysms of irritability disturb him; and his malady makes rapid advances; sometimes, however, seeming to recede, but always, in reality, making progress to more and more indistinct speech, greater loss of general muscular power, and increased feebleness of mind. Nutrition goes on well, and the exhilaration of the spirits often remains when the patient can no longer walk, or speak so as to be understood. Although, by care, the patient's life may be prolonged for some years, I believe this form of malady to be incurable. Its usual denomination is General Paralysis. It might, I think, be more correctly called the Paralysis of the Insane. I have never known it exist without mental disorder.

The Insanity of Old Age is another form of disease incidental to persons of very various intellectual power; coming on in some instances even before the age of sixty, but more usually in much more advanced periods of life. It is often characterised by melancholy, a fear of poverty, and paroxyms of maniacal excitement

associated with the memory of past years; followed by a tranquil state of imbecility, in which the most familiar faces and places are feebly recognised, or not at all.

Divisions of insanity have sometimes been based on mere varieties of its mode of manifestation; as Pyromania, characterised by a propensity to set fire to buildings, &c.; Kleptomania, with a propensity to theft. But in these cases, as in others where the prevailing tendency is to homicide, &c. a full investigation generally reveals wider impairment of the mind. Even the terms Monomania, or madness on one subject only, and Moral Insanity, or exclusive disorder of the moral feelings, have been far too extensively applied, and with some inconvenience; although their precise distinction is important in relation to crime. The occupations and amusements of the insane are often as fixed and determined as their more serious propensities. One man is always writing letters; another engaged in calculations; music alone delights others; and gardening and various work form to most of them the chief solace of their lives. Some are only active in devising mischief, and others, more disordered in intellect, talk and write with curious incoherence.

The state of Delusion, although common to so many cases, seems at first sight the most unaccountable of all the phenomena of madness: but its nature affords perhaps the clearest illustration of what Unsound Mind really is. A mere definition of insanity seems impossible. Unsound Mind, being the converse of Sound Mind, is a complicated state: for soundness of mind depends on the integrity and due relation to each other of many faculties; and it is the impairment of this integrity and the interruption of this due relation which constitutes unsoundness of mind. Such impairment may primarily exist in the sensations, or in the attention, or in the imagination, or in the memory, or in the affections and propensities; but it is the degree of the impairment, and the obstruction it creates to comparing and judging, which make the mind unsound, and lead to irrational conclusions and conduct. The various shades of insanity depend upon the extent and nature of the impairment of any of the faculties, and the degree in which it interrupts their due and co-ordinate exercise, and impedes due comparison and consequently perverts the judgment.

Several instances are recorded of persons being subject to ocular or aural hallucinations, or to both together, and for a length of time; but yet continuing sensible that they were only hallucinations. If the figures and voices are judged to be real in any case, the mind is on that subject unsound; and the consequences of this unsoundness are often dangerous. When the hallucinations are recognised to be hallucinations, the person can compare them with realities, and his judgment concerning them is correct. When they are believed to be real, this power of comparing is lost, and the judgment is incorrect, and the resulting conduct is that of an insane person. The soliloquy of Macbeth, when, in the agitation of his mind before the murder of the king, he imagines that a dagger appears

before him, furnishes a remarkable illustration of the struggle between delusion and reality, and the final triumph of the exercise of the comparing faculty. After the murder, he is less successful; and he believes that the ghost of Banquo fills a chair at the supper-table, although none of his guests are discomposed. For the time, and to that extent, he is then of unsound mind.

This kind of illustration might be extended to cases in which not the senses, but the memory, or even the affections or propensities, are primarily affected: but it is always to be remembered, that it is the degree in which any faculty is impaired, and the extent of its influence over the judgment, and the form and tendency of the resulting actions, which justify interference. A man may think his figure changed, or his rank; or he may believe in monitory voices addressed to him alone; and yet his conduct may be harmless, and he may possess, as regards his property, a sound disposing mind.

We endeavour, but without success, to find any intelligible explanation of the mental functions in health, or their disturbance in disease, in what anatomy or physiology have taught us respecting the arrangements and functions of nerves, or ganglia, or the brain. The distinct character and office of the vesicular or grey matter of the nervous substance, and the fibrous or white matter, have been clearly established: the recipient and governing character of the vesicular portion; and the messenger-office of the nerve-fibres, with its impassable limits as regards the offices of different fibres and different nerves. The functions of the spinal cord and the nerves proceeding from it; the reflex actions apparently originating in it, independently in ordinary cases, of the brain, and yet not dissociated from it; the offices of the complicated system called ganglionic or sympathetic, extending over important functions distinct from those of the spinal cord, and yet implicated with them, and not depending on the brain or will, and yet, in various exigencies, influenced by them; the various arrangement of the vesicular matter in the ganglia, and in the spinal column, and in the separate masses at the base of the brain, and in the larger mass of the brain itself; have all been investigated with the utmost patience and skill. Many general conclusions, and some more minute and precise, have been arrived at. Nerves of motion have been distinguished from nerves of sensation, and traced to distinct portions of the spine; the function of respiration, indispensable to life, has been found to depend on the integrity of a point of grey or vesicular matter in the medulla oblongata; the co-ordinate motion of the muscles has been assigned as one of the uses of the cerebellum; the sense of sight has been proved to be lodged in the smaller masses called the corpora quadragemina; and, in the higher animals, all these functions are known to be subservient to and dependent on the integrity of the brain for their continuance; whilst to this superadded and large portion of the nervous system we assign the manifestation of the propensities, of the affections, and of the mental faculties of man; as, without a brain, there is no intellectual life. An influence extends from or to

the vesicular portions of nervous matter, transmitted along the nervous fibres. If a nerve of sensation or of motion is divided, sensation and motion no longer exist below the divided part; if the spinal column is injured, the parts supplied with nerves from portions of it below the injured portion are deprived of motion and of sensation. If the medulla oblongata is severely injured, respiration ceases. If the brain itself is variously injured or diseased, the sensations become untrue, the movements irregular, all the bodily functions usually suffer more or less disorder, and the mental faculties are variously impaired. But as nothing that we know of the optic nerve and its association with the corpora quadragemina explains the wonders of sight or the sense of the beautiful; and as the auditory nerve and its origins have no intelligible relation to the sense of melody: so, in equal ignorance, we curiously examine the convolutions of the brain, and fail to discover the repositories of memory, or any clue to its capricious failures or revelations. We are incapable of conceiving the connection between these arrangements of matter and the tender affections and divine fancies which are among the privileges of man. The inspiration of the painter or sculptor, the reasonings of the philosopher, the calculations of the astronomer, are, we know, dependent on certain states or actions in these elementary nervous tissues, but we feel that we have not advanced one step to knowing how. Here, as in all branches of enquiry fully pursued, we seem to arrive at the confines of material existence, and can but conjecture a finer agency, of which we only see the effects.

We therefore return and rest upon the idea that the various forms of Insanity may depend upon the excess, or deficiency, or inequality, of this nervous agency, whatever it is, in different portions of the nervous system. We find that thinking and muscular exertion equally produce fatigue and exhaustion; and that sleep is the general restorer of power in both cases. Various states of bodily disease declare its partial or imperfect distribution, temporarily or permanently; the consequences being, increased, or deficient, or irregular action. The maniac seems often to require no sleep; the hysteric and the epileptic drop asleep after strong nervous excitement; and in patients affected with delusions, it is impossible not to recognise analogies which make their condition appear to be a state in which some of the faculties are not awake like the rest. The effects of stimulants and narcotics support the same view; and if we could comprehend the manner in which, by the inhalation of certain vapours and gases, all the relations between the external world and the brain are modified, we might arrive at some less vague notion than we possess of the actual condition of the nervous system both in health and disease. Disordered secretions, and a diseased state of the blood, may readily be supposed to act on the nervous system in such a manner as to disturb its functions; and the intimate and universal association of blood-vessels with nerves is additionally illustrated by the almost invariable combination of

nervous disorder with imperfection or excess in the circulating system.

Although the doctrines of the phrenologists have met with little favour, and the pretensions of recent professors of occult methods of acting upon the nervous system have thrown an air of absurdity even over the truths of what is called phrenology, no person not altogether devoid of the power of observation can affect to overlook the general importance of the shape and even of the size of the brain in relation to the development of the mental faculties. The head of an idiot always manifests defect in one of these particulars, if not in both. The head of a lunatic is irregularly developed in a very large majority of instances; and in the worst cases of insanity, where the tendency of the disorder is to pass into dementia, the anterior lobes of the brain are very defective. If we refuse to admit that the constitution, size, and shape of the brain have any relation to or connection with the extraordinary manifestation of particular faculties, in various instances, independently of all education, we must deny that the large lobes of the brain in man are of any use at all in relation to faculties which are certainly not seated in other portions of the nervous system. It is more reasonable to consider each of the large and marked divisions of the brain, and each of the convolutions, with their copious supply of grey or vesicular nerve-substance, as possessing distinct offices; and the more or less perfect development of these several masses, and the greater or less nervous energy they possess, as circumstances connected with the varieties of mental character, and with the disordered manifestations of the mind. Each mass, or each subdivision of such masses, may, like each nerve, have a distinct office. Each, however excited, may only be capable of one kind of manifestation of the excitement. Each, when in a healthy state, may be excited simultaneously throughout; and each in disease may be excited irregularly, or too long, or lose the power of being excited altogether.

But, leaving these speculations or analogies, where so much is obscure, experience has taught us that the violent emotions and passions of the mind, and propensities rendered masterly by indulgence, and the undue and exclusive employment of certain intellectual faculties, tend to produce disturbances in the functions of the brain, — to confuse the reason, to disorder the affections, and to degrade man to the dust. The reason and sense which we boast of should be employed therefore to secure *itself* amidst the shocks and blows incidental to the battle of life, and to guide the whole mind temperately through the sunshine and the storm. Well ordered affections, well directed aspirations, worthy and practicable objects, the pursuit of truth, and the desire to do good, — these things exercise, but do not discompose the understanding. Patience under trials which must come to all, and a trustful hope of a higher life after this life,— these things do not lead to mental derangement. But all vehement passions, and mere worldly ambition, and frettings

and envyings, and jealousies and care, and fits of wild impulsive enthusiasm, however directed, — these things carry tumult into the brain, and lead to madness. However ignorant we may be of the primary changes in the brain induced by such injudicious exertion of its functions, we may at least gather wisdom from a consideration of their undoubted results. [J. C.]

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## WEEKLY EVENING MEETING,

Friday, February 24.

Sir John P. Boileau, Bart. F.R.S. F.S.A. Vice-President, in the Chair.

Henry Bence Jones, M.A., M.D., F.R.S.

*On the Acidity, Sweetness, and Strength of different Wines.*

In the Philosophical Transactions for 1811 and 1813 Mr. Brande has given a table of the strength of wine, beer, and spirits : if these fluids acted on the system only as stimulants, no further experiments would be required to enable any one to determine their comparative medicinal and dietetic values ; but wine and beer contain many other substances besides spirit and water. Acids, sugar, æthers, salts, and colouring matter are all also present in varying proportions ; and it must at least be known which wine or beer is most sweet, and which is most acid, as well as which is most strong, before any satisfactory answer can be given whether port or sherry, claret or champagne, bitter beer or brandy should be taken. It would also be very desirable that the amount of salts and volatile æthers should also be known ; but the large quantity of fluid requisite for the analyses renders the questions relative to these substances still more difficult to answer.

I. *On the Acidity of different liquids.*

Hitherto, though acid is as invariably present as alcohol, very few observations have been made on the acidity of different wines. In Dr. Henderson's work on wine, Dr. Prout has given four determinations of the amount of acid in Rhine wine.

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|---|---|---|---|
| Johannisberger, 1788 | contained | 4,1 grs. | { Tartaric acid by weight in an ounce of wine. |
| Rudesheimer, 1811 | " | 2,7 grs. | |
| Rhenish | " | 4,6 grs. | |
| Same | " | 4,4 grs. | |

Professor Liebig in a paper on Australian Wines gives

| | | | | |
|---|---|---|---|---|
| Verdeilho and la Follie | " | 2,1 grs. | " | " |
| La Follie and Muscat | " | 2,6 grs. | | |
| White Muscat Lunel | " | 2,8 grs. | | |
| Verdeilho | " | 2,5 grs. | | |
| Riesling | " | 1,2 grs. | | |

| | | | |
|---|---|---|---|
| Irrewang, Pineau Noir, Tinta Pineau gris | | 2,2 grs. | Tartaric acid by weight in an ounce of wine. |
| Irrewang white | " | 2,9 grs. | |

Fresenius in the Annalen der Chemie, 1847, gives

| | | | | |
|---|---|---|---|---|
| Hattenheimer | " | 2,4 grs. | " | " |
| Marcobrunner | " | 2,3 grs. | | |
| Steinberger | " | 2,1 grs. | | |
| Choice Steinberger | " | 1,8 grs. | | |

For determining the amount of acid stated in the following tables, a standard solution of caustic soda was prepared, so that each division of the graduated tube contained 0,15 grs. of caustic soda; a thousand grain bottle was filled with the fluid to be examined; it was then weighed, and the quantity of test alkali necessary for neutralisation was determined by Clarke's test paper. In the tables, the acidity, although manifestly due to the presence of several acids, is by calculation reduced to the standard of tartaric acid in an ounce of fluid. The particular wines and the number of each kind will be there stated.

The following general results were obtained:

The quantity of alkali required to neuturalise a measure equal to 1000 grs. of water was —

| | | | | |
|---|---|---|---|---|
| In Port wine | " | " | 2,10 grs. | to 2,55 grs. |
| In Sherry | " | " | 1,95 | to 2,85 |
| In Champagne | " | " | 2,40 | to 3,15 |
| In Claret | " | " | 2,55 | to 3,45 |
| In Madeira | " | " | 2,70 | to 3,60 |
| In Rhine wine | " | " | 3,15 | to 3,60 |
| In Burgundy | " | " | 2,55 | to 4,05 |
| In Moselle | " | " | 2,85 | to 4,50 |
| In Geneva | " | " | 0,07 | |
| In Whiskey | " | " | " | |
| In Brandy | " | " | 0,15 | to 0,60 |
| In Rum | " | " | 0,15 | to 0,30 |
| In Pale Ale | " | " | 0,90 | to 1,65 |
| In Stout | " | " | 1,35 | to 2,25 |
| In Porter | " | " | 1,80 | to 2,10 |
| In Cider | " | " | 2,85 | to 3,90 |

Hence proceeding from the least acid wine to the most acid we have Sherry, Port, Champagne, Claret, Madeira, Burgundy, Rhine wine, Moselle. The least acid fluids examined were Geneva and Whiskey; then Rum, Brandy, Ale, Porter, Stout; the wines were all more acid than the malt liquids.

The nature of the acid was not absolutely determined, but a volatile acid distils over from wine, which is not acetic acid; and the action of polarised light shews that tartaric acid is seldom present; hence the fixed acid is most probably racemic and perhaps malic acid.

II. *On the Sweetness of different liquids.*

That sugars are of different kinds is easily seen by the different effects of the same test; but the most delicate test of all is polarised light. There are three different kinds of sugar, which when present in different solutions in equal quantities rotate the polarised ray in different degrees and directions. Cane sugar rotates the light to the right ⟶, and if treated with acid for a few minutes it is entirely changed into sugar which rotates to the left ⟵. This is called uncrystallisable sugar; for if the solution be even evaporated to dryness, it is changed into sugar which again rotates to the right ⟶. This sugar is called grape sugar or glucose, and this undergoes no change when again treated with acid.

By means of the saccharometer of Soleil the degree of rotation to the left or right can be measured, and thus the quantity of sugar in a solution can be determined; with cane sugar alone the results are probably perfectly accurate. With the other sugars the results are not yet so fully established: still at least the minimum amount will be obtained. It is essential that the fluids to be examined should be decolorised first with one tenth of a solution of subacetate of lead, and afterwards if requisite with animal charcoal.

Previous to the determination of the quantity of sugar present in these liquids, when decolorised they were examined by other tests for sugar, by the sulphate of copper test, by the liquor potassæ test, and with the polariscope. I found no Sherry, Port, Madeira, or Champagne that did not contain more or less uncrystallisable sugar; two samples of sherry excepted which were free from any sugar. I met with no Claret, Burgundy, Rhine, or Moselle wine, excepting only one sample of Sauterne, which was not free from every kind of sugar. Usually spirits contain no sugar; but one specimen of genuine French brandy had some cane sugar added to it. All kinds of Ale, Porter, and Stout contain much glucose. Hard cider I found also to be perfectly free from sugar. Sweet cider contained uncrystallisable sugar.

The particular results will be given in the Tables; the general results may be here stated.

| | Degrees | | | Amount of Sugar in an ounce of fluid. |
|---|---|---|---|---|
| In Sherry the sugar varied from | 2 to 9 | ⟵ | = | 4 grs. to 18 grs. |
| Port | 8 to 17 | .. | = | 16 to 34 |
| Madeira | 3 to 10 | .. | = | 6 to 20 |
| Malmsey Madeira | 28 to 33 | .. | = | 56 to 66 |
| Tokay | 37 | .. | = | 74 |
| Samos | 44 | .. | = | 88 |
| Paxarete | 47 | .. | = | 94 |
| Cyprus | 51 | .. | = | 102 |
| Champagne | 3 to 14 | .. | = | 6 to 28 |
| Sweet Cider | 9 to 22 | .. | = | 18 to 44 |
| Bitter Ale | 12 to 130 | ⟶ | = | 12 to 130 |
| Porter | 23 to 40 | .. | = | 23 to 40 |
| Stout | 45 to 64 | .. | = | 45 to 64 |

The fluids examined may be arranged in the following order, commencing with those which contain no sugar, and ending with the most saccharine.

Geneva, Rum, Whiskey, Claret, Burgundy, Rhine, Moselle. These have no sugar. Brandy, Sherry, Madeira, Champagne, Port, Cider, Porter, Stout, Malmsey, Ale, Tokay, Samos, Paxarete, Cyprus.

III. *On the Strength of different liquids.*

Having determined the acidity and the sweetness, the strength of these fluids was the next object of experiment. This was effected by an alcoholometer invented by M. Geisler of Bonn, which depends on the tension of the vapour of the fluid to be examined forcing up a column of mercury. To shew how nearly the results obtained by this instrument agreed with those obtained by the ordinary process of distillation, comparative experiments were made on the same wine: Thus

| | By distillation (Mr. Witt) per cent. by measure. | By Alcoholometer per cent. by measure. |
|---|---|---|
| Port 1834 | 22,46 | 23,2<br>23,5 |
| Sherry, Montilla | 19,95 | 20,7<br>20,6<br>20,6 |
| Madeira | 22,40 | 23,5<br>23,2 |
| Haut Brion Claret | 10,0 | 11,1<br>11,1 |
| Chambertin | 11,7 | 13,2<br>13,0 |
| Low quality Sherry | 20,7 | 21,1<br>20,9 |
| Brown Sherry | 23,1 | 23,0<br>23,3 |
| Amontillada | 20,5 | 21,0<br>21,0 |
| Mansanilla | 14,4 | 15,4<br>15,4 |
| Port Best | 20,2 | 21,1<br>21,0 |
| Marcobrunner | 8,3 | 9,7<br>9,5 |
| Home Ale | 6,4 | 7,0<br>7,1 |
| Export Ale | 6,4 | 7,0<br>6,9 |
| Strong Ale | 9,0 | 10,7<br>10,8 |

Generally it may be stated, from my experiments, that the alcohol varied

| | Per cent. | | Per cent. by measure. |
|---|---|---|---|
| In Port from | 20,7 | to | 23,2 |
| Sherry | 15,4 | | 24,7 |
| Madeira | 19,0 | | 19,7 |
| Marsala | 19,9 | | 21,1 |
| Claret | 9,1 | | 11,1 |
| Burgundy | 10,1 | | 13,2 |
| Rhine Wine | 9,5 | | 13,0 |
| Moselle | 8,7 | | 9,4 |
| Champagne | 14,1 | | 14,8 |
| Brandy | 50,4 | | 53,8 |
| Rum | 72,0 | | 77,1 |
| Geneva | 49,4 | | |
| Cider | 5,4 | | 7,5 |
| Bitter Ale | 6,6 | | 12,3 |
| Porter | 6,5 | | 7,0 |
| Stout | 6,5 | | 7,9 |

The particular kinds of wine or beer examined as to acidity, sweetness, and strength, are recorded in the following tables :—

TABLE I.

| PORT. | Tartaric Acid per Ounce. | Sugar per Ounce. | Alcohol per cent. | Specific gravity. |
|---|---|---|---|---|
| A. quality from importer | 4,0 grs. | 22 grs. | 21,1<br>21,0 | 993,2 |
| A. quality | 4,2 | 18 | 21,3<br>21,3 | 990,2 |
| General | 4,0 | 20 | 21,0<br>21,0 | 991,8 |
| Low | 4,3 | 16 | 21,7<br>21,8 | 992,6 |
| Very fine | 3,6 | 34 | 23,2<br>23,2 | 996,2 |
| Low | 4,0 | 24 | 22,6<br>22,5 | 1003,4 |
| G. B. Port | 3,6 | 28 | 20,8<br>20,7 | 996,6 |
| Roussillon | 5,0 | 30 | 20,7<br>20,7 | 996,6 |

TABLE II.

| SHERRY. | Tartaric Acid per Ounce. | Sugar per Ounce. | Spirit per cent. | Specific gravity. |
|---|---|---|---|---|
| J. C. . . . | 3,6 grs. | 6 grs. | 18,5<br>18,5 | 990,5 |
| Low light . . | 3,8 | 6 | 21,1<br>20,9 | 988,8 |
| Golden low . . | 4,2 | 12 | 23,2<br>23,2 | 991,1 |
| Golden better . . | 4,3 | 10 | 21,4<br>21,4 | 992,9 |
| General light . . | 3,7 | 4 | 21,1<br>21,0 | 988,2 |
| Best . . . | 3,6 | 6 | 21,2<br>21,1 | 990,0 |
| Low brown . . | 4,5 | 18 | 23,0<br>23,3 | 997,1 |
| Very low light . . | 3,4 | 10 | 21,8<br>22,1 | 987,9 |
| Very low dark . . | 4,2 | 12 | 24,6<br>24,7 | 991,2 |
| C. Golden . . | 3,6 | 4 | 17,4<br>17,3 | 988,7 |
| B. Good . . | 4,8 | 16 | 20,2<br>20,2 | 997,0 |
| Light A. quality Amontillada . . . | 3,7 | 4 | 20,7<br>20,6 | 985,3 |
| B. Amontillada . . | 3,5 | 10 | 17,0<br>17,0 | 992,4 |
| F. Amontillada very good | 3,3 | 0 | 21,0<br>21,0 | 984,0 |
| B. Mansanilla . . | 4,3 | 2 | 15,7<br>15,6 | 987,8 |
| C. Mansanilla . . | 4,5 | 6 | 16,6<br>16,6 | 992,2 |
| | 4,5 | 6 | 16,8<br>16,8 | 990,0 |
| T. Mansanilla . . | 4,3 | 4 | 19,3<br>19,0 | 988,0 |
| G. Mansanilla . . | 3,5 | 0 | 15,4<br>15,4 | 989,2 |

## TABLE III.

| MARSALA. MADEIRA. | Tartaric Acid per Ounce. | Sugar per Ounce. | Spirit per cent. | Specific gravity. |
|---|---|---|---|---|
| Paxarete imported direct, 12 years old | 3,6 grs. | 94 grs. | 18,8 / 18,9 | 1039,9 |
| B. Marsala, 1847 | 4,3 | 10 | 21,0 / 21,1 | 990,5 |
| I. Marsala | 4,3 | 10 | 20,0 / 19,9 | 990,9 |
| Lisbon | 4,8 | 6 | 19,0 / 19,1 | 989,0 |
| Teneriffe | 5,0 | 8 | 20,6 / 20,7 | 990,0 |
| Madeira 17 years in bottle at Ceylon | 5,0 | 6 | 19,7 / 19,7 | 991,2 |
| Madeira three times in East Indies | 4,5 | 16 | 19,2 / 19,0 | 996,3 |
| Madeira direct | 4,8 | 20 | 19,1 / 19,0 | 994,8 |
| Madeira Agoa de Mellos | 12,0 | 66 | 19,8 / 19,8 | 1012,0 / 1011,9 |
| Malmsey Madeira | 10,0 | 56 | 18,8 / 18,7 | 1046,4 |
| Tokay | 9,0 | 74 | 16,0 / 16,0 | 1016,8 |
| Samos | 10,8 | 88 | 15,1 / 15,0 | 1050,1 |
| Cyprus | 10,8 | 102 | 15,4 / 15,5 | 1041,4 |
| Shiraz | 5,0 | 16 | 18,3 / 18,4 | 996,8 |

## TABLE IV.

| CLARET AND BURGUNDY. | Tartaric Acid per Ounce. | Sugar per Ounce. | Spirit per cent. | Specific gravity. |
|---|---|---|---|---|
| T. Medoc | 5,0 grs. | 0 grs. | 9,4 / 9,1 | 995,4 |
| L. and S. Medoc, 24*s.* | 5,8 | 0 | 9,7 / 9,6 | 995,1 |
| Medoc 36*s.* | 5,3 | 0 | 10,0 / 9,9 | 995,3 |
| Talbot St. Julien, 48*s.* | 5,3 | 0 | 9,1 / 9,1 | 995,3 |
| Haut Brion | 4,3 | 0 | 11,1 / 11,1 | 994,3 |

TABLE IV. *continued.*

| CLARET AND BURGUNDY. | Tartaric Acid per Ounce. | Sugar per Ounce. | Spirit per cent. | Specific gravity. |
|---|---|---|---|---|
| Claret 60*s*. . . | 4,8 grs. | 0 grs. | 10,5 / 10,5 | 994,4 |
| Chambertin 84*s*. . . | 4,3 | 0 | 13,2 / 13,0 | 993,0 |
| Macon, (red) 40*s*. . | 5,5 | 0 | 10,5 / 10,4 | 994,4 |
| Grave (white) 42*s*. . | 6,8 | 0 | 10,1 / 10,1 | 997,4 |
| Sauterne 72*s*. . . | 5,5 | 5 | 13,6 / 13,5 | 996,7 |
| B. Sauterne . . | 6,8 | 0 | 14,5 / 14,3 | 998,1 |

TABLE V.

| HOCK, MOSELLE, CHAMPAGNE. | Tartaric Acid per Ounce. | Sugar per Ounce. | Spirit per cent. | Specific gravity. |
|---|---|---|---|---|
| Rudesheimer, 1834 . | 5,3 grs. | 0 grs. | 11,7 / 11,7 | 994,3 |
| Marcobrunner Cabinet 1818 . . . | 6,0 | 0 | 9,7 / 9,5 | 996,5 |
| Steinberger, 1846 . | 5,3 | 0 | 12,9 / 13,0 | 992,5 |
| Geisenheimer, 1842 . | 5,8 | 0 | 10,6 / 10,6 | 994,9 |
| MOSELLE. | | | | |
| Brauneberger, 1842 . | 7,6 | 0 | 9,4 / 9,4 | 995,3 |
| Scharzhofberger, 1843 . | 4,8 | 0 | 8,7 / 8,7 | 995,3 |
| CHAMPAGNE. | | | | |
| Sillery Mousseux Première qualité . . | 4,9 | 24 / 24 | 14,8 / 14,7 | 1011,8 |
| Sparkling, 48*s*. | 4,6 | 28 / 28 | 14,3 / 14,1 | 1021,7 |
| Moet's first quality, 1846, 80*s*. . . . | 5,2 | 24 / 24 | 14,5 / 14,4 | 1014,2 |
| Moet's Still dry Sillery, 1842, 110*s*. . . | 4,0 | 6 | 14,5 / 14,5 | 989,2 |

## Table VI.

| SPIRITS, LIQUEURS. | Tartaric Acid per Ounce. | Sugar per Ounce. | Spirit per cent. | Specific gravity. |
|---|---|---|---|---|
| Best Brandy . . | 1,1 grs. | 4,4 grs. | 53,6 / 53,8 | 930,1 |
| Cheap Brandy . . | 0,27 | 0 | 52,0 / 52,0 | 933,3 |
| Calais Brandy . . | 1,1 | 0 | 50,6 / 50,4 | 932,6 |
| Cognac . . | 1,1 | 0 | 52,6 / 52,4 | 928,9 |
| Thompson Brandy . | 1,1 | 0 | 51,2 / 51,0 | 930,8 |
| Best Rum . . | 0,56 | 0 | 72,2 / 72,0 | 885,4 |
| Cheap Rum . . | 0,56 | 0 | 77,1 / 77,1 | 874,6 |
| Geneva . . . | 0,18 | 0 | 49,4 / 49,4 | 932,8 |
| Whiskey, Highland . | 0,18 | 0 | 59,4 / 59,2 | 915,5 |
| Noyau . . . | 0 | 150 | 29,4 / 29,4 | 1159,4 |
| Curaçoa . . | 0 | ? | 46,0 / 46,0 | 1101,8 |
| Maraschino . . | 0 | 120 | 36,8 / 37,0 | 1113,1 |

## Table VII.

| CIDER From Stockland, near Honiton. | Tartaric Acid per Ounce. | Sugar per Ounce. | Spirit per cent. | Specific gravity. |
|---|---|---|---|---|
| A. medium quality Hard best. . . . | 6,0 grs. | 0 grs. | 7,5 / 7,4 | 998,1 |
| B. Hard . . . | 6,5 | 0 | 6,8 / 6,8 | 1001,3 |
| C. Hard . . . | 5,8 | 0 | 6,0 / 6,0 | 998,5 |
| D. Hard . . . | 5,0 | 0 | 7,1 / 7,1 | 999,0 |
| L. Sweet . . | 6,2 | 18 | 6,8 / 6,7 | 1005,2 |
| W. Sweet . . | 4,7 | 20 | 5,4 / 5,4 | 1006,7 |
| S. Sweet . . | 5,5 | 44 | 6,5 / 6,5 | 1013,8 |
| N. Sweet . . | 5,9 | 36 | 6,6 / 6,6 | 1012,6 |

### Table VIII.

| PORTER, STOUT. | Tartaric Acid per Ounce. | Sugar per Ounce. | Spirit per cent. | Specific gravity. |
|---|---|---|---|---|
| Y. Mild Porter . . | 3,4 grs. | 34 grs. | { 6,6 / 6,6 } | 1011,0 |
| Bottled Porter . . | 3,4 | 23 | { 6,5 / 6,5 } | 1009,4 |
| Stout . . . | 3,7 | 49 | { 9,8 / 9,8 } | 1017,9 |
| Mild Stout . . | 3,2 | 64 | { 8,0 / 8,0 } | 1027,1 |
| N. Porter, 18 months . | 3,2 | 37 | { 6,7 / 6,6 } | 1011,0 |
| Porter, 3 months . | 3,0 | 40 | { 7,0 / 6,8 } | 1015,0 |
| Stout, 18 months . | 3,7 | 45 | { 7,8 / 7,9 } | 1014,0 |
| Stout, 3 months . | 3,7 | 60 | { 6,9 / 6,9 } | 1023,7 |

### Table IX.

| BITTER ALE. | Tartaric Acid per Ounce. | Sugar per Ounce. | Spirit per cent. | Specific gravity. |
|---|---|---|---|---|
| T. Pale Ale, Nov. 1852 . | 2,0 grs. | 12 grs. | { 8,1 / 7,9 } | 1003,8 |
| Family Ale, Dec. 1852 . | 1,8 | 14 | { 6,6 / 6,6 } | 1002,9 |
| Strong Ale, Oct. 1852 . | 2,7 | 45 | { 10,5 / 10,5 } | 1016,7 |
| Stout, Dec. 1852 . | 2,2 | 42 | { 8,8 / 8,8 } | 1017,2 |
| S. Pale Ale, March 1853 | 1,5 | 45 | { 6,8 / 6,7 } | 1011,8 |
| Pale Ale, Dec. 1851 . | 2,5 | 35 | { 7,2 / 7,1 } | 1008,6 |
| Pale Ale, strong, Jan. 1853 | 1,7 | 103 | { 11,0 / 10,9 } | 1034,6 |
| P. Pale Ale, 5 months . | 1,5 | 40 | { 7,7 / 7,5 } | 1011,4 |
| Pale Ale, 18 months . | 1,8 | 30 | { 7,1 / 7,2 } | 1007,8 |
| Arctic Ale, very strong . | 2,7 | 83 | { 12,4 / 12,3 } | 1023,4 |
| Home Ale . . | 1,5 | 40 | { 7,0 / 7,1 } | 1010,6 |
| Export Ale . . | 1,5 | 43 | { 7,0 / 6,9 } | 1011,7 |
| Strong Ale . . | 2,2 | 100 | { 10,8 / 10,7 } | 1029,2 |

*The salts and æthers and colouring matters* are also very important ingredients of wine, but as yet very little information has been obtained regarding them. As to the salts in the fluids examined, it is evident that Brandy and the other spirits, from the mode of their preparation, should contain no salts. In wine the salts must be very different in different kinds of wine, or even from grapes cultivated on different soils. The nature of the ashes of the wine may be conjectured from the ashes of the juice of the grapes.

In 100 parts of must or juice of grapes there have been found

| | Purple grapes ripe on Porphyry. | Purple grapes ripe on other soil. | Green grapes ripe on Porphyry. |
|---|---|---|---|
| Potassa | 0,2122 | 0,2939 | 0,1819 |
| Soda | 0,0014 | 0,0049 | 0,0077 |
| Lime | 0,0114 | 0,0139 | 0,0148 |
| Magnesia | 0,0161 | 0,0163 | 0,0115 |
| Oxide of Iron | 0,0015 | 0,0003 | 0,0012 |
| Oxide of Manganese | 0,0025 | 0,0004 | 0,0009 |
| Phosphoric Acid | 0,0564 | 0,0575 | 0,0494 |
| Sulphuric Acid | 0,0189 | 0,0149 | 0,0142 |
| Chlorine | 0,0035 | 0,0020 | 0,0020 |
| Silica | 0,0071 | 0,0049 | 0,0064 |
| | 0,3400 | 0,4090 | 0,2900 |

The variations of the salts in each kind of wine have yet to be determined.

The same may be said of Beer; the ash of one kind analysed by Mitscherlich was 0,307 in 100 parts of beer.

| | | |
|---|---|---|
| In 100 parts of ash he found | Phosphoric acid " | 20.0 |
| | Potassa " " | 40,8 |
| | Soda " " | 0,5 |
| | Phosphate of Magnesia | 20,0 |
| | Phosphate of Lime " | 2,6 |
| | Silica " " | 16,6 |

For many other analyses of the ash of beer see translation of Liebig's Annual Report for 1848, p. 318.

Of the *æthers* still less is known. The œnanthic æther exists in all wine; it has a peculiar smell which is not vinous. The œnanthic acid is identical with Pelargonic acid, which is obtained from Pelargonium roseum, and it may be formed artificially by oxydation of oleic acid, or from the ætherial oil of rue. Other volatile æthers exist in wine; for example, in Bordeaux wine acetic æther, butyric æther, and valerianic æther. Each wine like each fruit has probably its own peculiar volatile principles; and as art has succeeded in imitating if not in actually forming the odoriferous principles of many fruits, as the pear, (acetate of oxide of amyl), of the pine-

**apple (butyric æther), of green-gage, of black currant, of grapes, so doubtless the characteristic essences of wine will before long be artificially prepared. But though the flavour of the wine is mainly dependent on the volatile principles, still the alcohol, water, and sugar, are also concerned in producing the effect; each substance plays its part; though as regards flavour all are inferior to the volatile constituents of the wine. This union of principles producing a single effect, is also to be observed in the colour of wine. The acid which is present in all wine plays an inferior but decided part in the production of the colour of the wine, for when the acid is neutralised, the colour of all wine is more or less deepened; in some clarets and sherries this is most conspicuous; so also cider becomes dark brown when neutralised.**

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**From what has been said it will be very evident that we are not yet possessed of sufficient knowledge to enable us to estimate accurately the action of wine and beer on the system. However, the two most important agents in fermented liquids are the alcohol and the acid.** If wine were only a stimulant, Mr. Brande's table would give sufficient information to enable us to decide on the comparative stimulating action of different liquids. In the preceding tables I have endeavoured to give the means of estimating the other important agent, namely, the acid of these fluids.

It is very probable that all sugar is converted in the stomach into acid. Some sugars are changed quicker than others,— cane-sugar the slowest; glucose or the sugar of beer the quickest. Hence to determine the acid action of wine the amount of sugar must be added to the amount of acid. In the wine that has no sugar, the full amount of acid immediately acts in the stomach; whilst in beer, in which there is much sugar and little acid, the full amount of acid is slowly produced in the stomach, but in the end is greater than in the more acid wine. In forming an opinion upon the acid action of these fluids the acid alone must not be considered, but the acid and sugar must be taken together. Thus, the following order may be observed in the fluids which were used for these experiments. Proceeding from the fluid producing least to that producing most acid:—

Geneva, Whiskey, Rum, Brandy, Claret, Burgundy, Rhine, Moselle, Sherry, Madeira, Champagne, Cider, Port, Porter, Stout, Ale, Malmsey, Tokay, Cyprus. In all dietetic or medicinal questions regarding these fluids, first, the stimulating properties, and secondly, the ultimate acidifying properties of these liquids must be considered. The above tables may at least assist in approximatively forming correct answers.

It is very evident from these tables that determinations of the water, alcohol, and sugar, though useful in relation to the stimulating and acidifying action of wine and beer, are of no use for determining the

quality of the wine. You cannot thus tell port from sherry; far less good port from bad port. If you look at the Port table the numbers are nearly identical. Mr. Brande's experiments were undertaken for the purpose of saying whether alcohol was added to the wine or not; whether it was natural or "fortified." It would be as easy to add salt to sea-water and then endeavour by chemistry to say which salt belonged to the sea-water and which was added.

In the last Report of the Committee of the House of Commons, it is stated that most wine is fortified with ten per cent. of brandy, and even as much as one sixth of all the spirit may be intermixed; more seldom grape-juice, evaporated wine, and elder-berry extract areadded. "Strong, black,and sweet" form the criterion of excellence, according to the Portuguese government; what we require at present is not this, but the exact chemical composition of unblended, unfortified vintage wines; until these are obtained we have no means of making true comparisons.

For the detection of most of the adulterations of wine at home and abroad, there is but one scientific method possible. This may be summed up in these words,—accurate comparison with standard wines: by means of these we shall be able to trust to the science of the chemist, whilst without them we can only depend on the skill of the taster acquired by use.

[H. B. J.]

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## WEEKLY EVENING MEETING,

Friday, March 3.

George Dodd, Esq., F.S.A., Vice-President, in the Chair.

Rev. Baden Powell, M.A., V.P.R.S., F.R.A.S., F.G.S.,
Savilian Professor of Geometry, Oxford.

### *On certain Phenomena of Rotatory Motion.*

The mechanical principle of "the composition of Rotatory Motion," originally discovered by Frisi about 1750, (see Frisius de Rotatione, Op. ii. 134, 157, and Cosmographia, ii. 24) is equally simple in its nature, important and fertile in its consequences and applications,—and susceptible of the easiest explanation and experimental illustration; yet it has been singularly lost sight of in the common elementary treatises. It is indeed discussed and applied in a Mathematical form in Mr. Airy's Tract on Precession (Math. Tracts, p. 192, 2nd ed.); and the theorem is stated by Professor Playfair in his "Outlines of Natural Philosophy" (i. 144), and its application explained (ib. ii.

308). These, however, are not books of a popular kind, and the author is not aware of any mention of it in other English works. In a more abstract analytical form it has been discussed by several foreign mathematicians, especially by Poinsot, in a Memoir read to the Academy of Sciences, May 19, 1834, but of which only an abstract was published; as well as by Poisson, in a paper in the Journal de l'Ecole Polytechnique (xvi. 247).

The principle is involved in the explanation of several important phenomena, some of which are in fact mere direct instances of it; so that a simple experimental mode of exhibiting it would be eminently desirable; and several such have accordingly been devised which yet seem to have been but little generally known.

An ingenious instrument of the kind was contrived some years ago by Mr. H. Atkinson, a very brief account of which is given in the Astronomical Society's Notices, vol. i. p. 43, though so brief that it is difficult to collect what the precise mode of its action was,—but it seems somewhat complex.

A far more complete and instructive apparatus was invented by Bonenberger and described in Gilbert's Annalen (lx. p. 60). It is also explained in some German elementary works. Attention has been more recently drawn to the subject by a highly interesting paper of Professor Magnus of Berlin, (Abhandlungen der Königl. Preuss. Akad. 1852, translated in Taylor's Foreign Scientific Memoirs, N. S. Part 3, p. 210,) in which some remarkable applications of this apparatus are given; he also describes it (with a figure) and observes that the execution of it requires great delicacy and correctness of workmanship. Copies of this instrument have indeed been made in this country (one of which was exhibited through the kindness of Professor Wheatstone); but of these the author believes no description has ever appeared in English works, and they are certainly very little known, notwithstanding their manifest value to every lecturer: the essential parts are a sphere capable of rotating about an axis whose extremities rest in opposite points of a hoop which can turn on pivots *horizontally*, within another hoop turning on pivots about a *vertical* line.

In fact the author of the present communication has long felt the want of such an apparatus for lecture illustration; and before he was aware of the existence of any of those just alluded to, had constructed one in a different form, and which is found to answer fully the purposes of illustration for which it is designed, without any nice workmanship or complex machinery. (See Astronomical Society's Notices, vol. xiii. p. 221-248.)

Its object, like that of the instrument last mentioned, is to exhibit experimentally *the actual composition of rotations about two different axes impressed at once on the same body.*

The essential parts are merely a bar capable of rotating freely about one end of an axis, (and loaded at its extremities to keep up the rotation,) while the axis itself can turn about a point in its

length near the end carrying the bar, upon a horizontal axis, capable of moving freely round a vertical pillar. At the lower end of the first axis is a weight which more than counterpoises the upper part.

If then there be no rotation in the bar about the first axis, the effect of the weight is to produce a rotation about the second alone, bringing down the first axis into a vertical position.

If now the first axis be held horizontally or obliquely, and a rotatory motion be given to the bar about it, on letting the axis go, *we compound both rotations;* and the resulting effect is, that the weight will no longer bring the axis *down*, or alter its *inclination* at all: but will cause it to take a new position, or make the whole to turn round the vertical, in a direction *opposite* to that of the rotation.

Thus, although confessedly not new in principle, to make public an experimental illustration in so simple a form may not be without its use for a great majority of students.

Even the theoretical principle is capable of being stated in a way quite intelligible to those acquainted only with the very first rudiments of theoretical mechanics, presenting itself in close *analogy* to that well known first principle, the composition of *rectilinear* motion.

As in this last case, if a body be in motion in one direction, and any cause tend to make it move in another, it will move in neither, but in an intermediate direction,—so we have the strictly analogous case in *rotatory* motion; *when a body is rotating about an axis, and any cause tends to make it rotate about another axis, it will not rotate about either, but about a new axis intermediate to the two.* Thus the result of compounding the two rotations will be, that the axis (carrying with it the rotating body) will simply take a new position, or will move in a direction determined by the nature of the impressed motions.

Professor Magnus, in the very able, but rather prolix and obscurely written Memoir, before referred to, speaks (p. 223) of the consequences of such a law as evinced in the resulting rotations, but without any distinct or explicit statement of the essential theorem of the composition of rotatory motion. He gives, however, some singular and even paradoxical exemplifications of it. We may allude to one of these, which is capable of being put into a form at once *more simple*, and at the same time *more paradoxical*, than that in which he describes it. It consists in this: a wheel at one end of an axis, and a weight at the other, are suspended in equilibrio; which is, of course, unaltered, whether the wheel be at rest or in rotation: the weight is then slid so that the balance is *destroyed: now* if the wheel be set in rapid *rotation*, the *equilibium is restored.* This is nothing but a simple case of the principle just stated, as shewn by the author's apparatus.

Besides certain other cases traceable to a different cause, Professor Magnus's immediate object is to explain a curious observed anomaly

in the motion of projectiles of an *elongated* form shot from *rifled* guns, and which consequently *rotate* about their axis, while passing through the air in the direction of that axis.

He mentions the fact that artillery experiments in different countries with rifled cannon and missiles of a cylindical form with a conical apex, *always shew a deviation of the point of the missile to the right, the rifle-spiral being right-handed.*

To explain the nature of this deviation was the object of special experiments on the part of the Prussian Artillery Commission, in which Professor Magnus assisted. The missiles were fired with low charges, so as to allow the motion to be accurately observed, and it was found that the axis remained sensibly in the direction of the tangent to the curved path, while the deviation to the right was always clearly marked. He observes that left-handed rifles have never been tried.

Professor Magnus, after some fruitless conjectures as to the cause, at length sought it in the principle of *the composition of rotatory motion.* He tried experimentally the effect of a current of air on a projectile of the form employed, by inserting such a body instead of the rotating sphere in Bonenberger's apparatus, and observing the effect on it, first at rest, and then in rotation, when the strong current of a blowing machine was directed against the conical apex. When at *rest,* the current *elevated* the apex; owing to the form of the missile the resistance acting not through the centre of gravity, but above it: when in *rotation* no *elevation* took place, but a *deviation* in the direction of the axis, in a direction opposite to that of rotation. To shew the application of the principle in this case, he observes that the axis of the elongated projectile, which for an instant coincides with the *tangent* to its curved path, momentarily changes its direction, so that the front extremity or apex falls below its former position. Or, for a single instant it may be regarded as if locally at rest, but turning about its centre of gravity so as to depress the apex.

If the motion were simply in the direction of the axis, the *resistance of the air* would operate directly against it; but when the apex is continually tending to turn *downwards* from that line, the resistance acts against it partially *upwards,* and thus tends to raise the apex.

Thus, at a given instant, the elongated projectile may be represented by the rotating part of the apparatus just described.

When there is *no rotation,* the resistance of the air tending to raise the apex is represented by the weight at the lower end, which produces the same effect.

When a rapid *rotation* is communicated, (suppose from left to right of the gunner,) the result will be, *no elevation* of *the apex,* but a *lateral* movement, or commencement of a rotation round the vertical,—in astronomical language *retrograde,* if the former rotation be *direct;*—but which beginning from the opposite part of the circle is, *relative to the operator,* towards the *right.*

The form of the projectile used in these experiments differs from that in the Minié rifle, in that the latter is hollow at its broader end, and thus the centre of gravity is thrown forward towards the apex. Hence, according to the same theory, the effect would probably here be to depress the apex, and therefore to give an opposite deviation: but it does not appear whether any such observations have been made; and in practice the effect would probably be quite insensible.

It occurred to the author that a very simple illustration of this deviation of rifle projectiles might be made by merely forming a sort of small arrow, whose head was composed of a cork, like a shuttlecock, but instead of the feathers, small card vanes inclined in the same direction round it, with a tail to balance it, and which thus in the mere act of throwing acquires a rotatory motion from the reaction of the air, to the right or left according as the vanes are inclined; and on trying this there was always observed a deviation in the direction of the axis or point of the missile to the right or left accordingly, relative to the experimenter. It is in fact nearly impossible to throw such a body in a direction perfectly in one plane. The true deviation is, however, peculiarly liable to be disguised by the general resistance of the air on so light a missile, as well as by currents, &c. which it is not easy to guard against.

The well known case of the *Boomerang* exhibits effects closely similar: for it is found that if so projected that its *rotation* is from left to right, its *deviation* will be in the *same direction*, and *vice versâ*: that is, supposing (as is the usual case) that its plane is inclined *upwards* from the operator:—If it be inclined *downwards*, the deviation is in the direction *opposite* to that of the rotation.

In the former case the reaction of the air against the flat surface of the missile would tend to increase its inclination *upwards*, in the latter *downwards*, with respect to the operator: and this in each case respectively would give the motion stated; as is easily seen on the principle, and by means of the apparatus, before described.

Thus it would follow that this extraordinary instance of savage invention, which long ago puzzled inquirers, is simply a case (like the last) of "the composition of rotatory motion."

It should, however, be mentioned that some experimentalists have entertained a different view of the cause of deviation in this instance.

Besides the results above stated, Professor Magnus (in the same Memoir) mentions several other highly curious cases produced by certain modifications of the apparatus; but all referrible to the same principles.

M. Fessel has also invented an apparatus (since called the Gyroscope) an account of which is given with some remarks by Professor Plücker, and the Editor in Poggendorff's Annalen (1853, Nos. 9 and 10), which though apparently invented without any knowledge of Bonenberger's apparatus, is a modification of it, referring to phenomena of the same kind as those of the equilibrium experiment mentioned at first.

This apparatus has been greatly improved upon by Professor Wheatstone, who has introduced other movements to include the conditions of rotation in different planes. One of these instruments was exhibited.

From these singular applications of a very simple mechanical truth, we may now turn to what is but another exemplification of the same thing, however apparently remote from those we have considered, and upon a far grander scale.

The phenomenon of the Precession of Equinoxes was known to Hipparchus; but no explanation of the fact was for ages imagined. Even Kepler, in the multiplicity of his hypothetical resources, could not succeed in devising anything plausible. The axis of the Earth is slowly shifting its position, so that its pole points continually to a new part of the heavens,—a new pole star,—at the rate of about 50″ a year, and of course carries with it the point of intersection of the Earth's equator with the ecliptic or plane of its orbit, at the same rate and in a direction opposite to that of its motion, or the order of the signs.

These phenomena remained wholly without explanation till Newton, led by the analogy of those disturbing forces on the orbit of a planet which cause its *nodes to regress*, shewed that the same would occur in a *satellite* to the earth,—in a *ring* of such satellites, —in such a ring adhering to the equator, or the protuberant part of the terrestrial sphere; and thus that the equinoctial points would slowly regress. (See Principia, i. 66, Corr. 11—22.)

The more exact determination of quantitative results was reserved for Newton's successors, when a more powerful analysis had been applied by Euler, D'Alembert and others to the full exposition of the theory, founded on general equations of motion; as since given in the writings of Laplace, (Mec. Cel. liv. xiv. ch. 1.) and Pontécoulant (Théorie du Systême du Monde, liv. iv. ch. 5.), which are necessary for including all the minuter variations detected by Bradley, and subsequent observers, shewing the *nutation* of the axis, and the inequalities of precession due to the varying configurations of the attracting luminaries.

These higher mathematical views, though of course the most complete and systematic, are not the most direct or easy mode of explaining the subject to the student. Greater simplicity certainly characterizes the method adopted by Mr. Airy (in the tract before cited) of applying *directly* the theorem of the composition of rotatory motion; as doubtless Newton would have done had it been known to him. But here, as in so many other instances, the first explanation presented itself mixed up with more complex considerations; and as has been well observed " simplicity is not always a fruit of the first growth."

To those not versed in the mathematical theory, of all points in Physical Astronomy, the " modus operandi" of the Precession, perhaps, usually seems the most paradoxical, and the explanations

given in some of the best popular treatises are seldom found satisfactory, following as they do the letter of Newton's illustration and omitting the *direct* introduction of the principle of composition, which, if only from what has been here offered, is at once seen to be easily capable of the most elementary explanation. Indeed it was from this consideration forcing itself on the mind of the author, in several courses of popular lectures on Astronomy, that he was led to seek the means of experimental illustration above described; and which would more palpably imitate the phenomena to the eye, if, instead of the rotating *bar* a terrestrial *globe* be substituted (as in Bonenberger's instrument)—for better illustration made protuberant at the equator,—where the weight at the south pole acts the part of the sun's and moon's attraction, to pull down the protuberant matter of the spheroid at the equator if at *rest*, but when combined with the earth's *rotation* results in a transference of the position of its axis, or slow revolution of its pole round the pole of the ecliptic in a direction opposite to its rotation, carrying with it the equinoxial points, and causing the *signs* of the zodiac to shift backwards from their respective *constellations*.

It always affords a sort of intellectual surprise, to perceive for the first time the application of some simple and familiar mechanical principle to the grand phenomena of astronomy: to see that it is but one and the same set of laws which governs the motions of matter on the earth and in the most distant regions of the heavens; to find the revolution of the apsides in a pendulum vibrating in ellipses, or the conservation of areas in a ball whirled round by a string suddenly shortened: or (as in the present case) to perceive a celestial phenomenon, vast in its relations both to time and space and complex in its conditions, identified, as to its mechanical cause, with the rotatory movement of a little apparatus on the table before us,—or to discover the Precession of Equinoxes in the deviation of a rifle or a boomerang. And the simple experimental elucidation of such phenomena and their laws will not be useless, as it tends to confirm in the mind of the student the great characteristic of the modern physical philosophy first asserted by Galileo, the identity of the causes of the celestial and terrestrial motions, and to aid and elevate our conception of those grand and simple principles according to which the whole machinery of the universe is so profoundly adjusted.

[B. P.]

## GENERAL MONTHLY MEETING,

### Monday, March 6, 1854.

Right Hon. BARON PARKE, Vice-President, in the Chair.

George Richard Burnett, Esq.
William Chapman, Esq.
George Clowes, Esq.
Thomas Davis, Esq.
Hananel De Leon, M.D.
Lt.-Col. Lothian Sheffield Dickson.
The Hon. Sir William Erle, Justice of the Court of Queen's Bench.
Richard Hoper, Esq.
Edmund C. Johnson, M.D.
Barry Charles Knight, Esq.
John Parrott, Esq.
Henry Pollock, Esq.
Charles Sartoris, Esq.
George Ward, Esq.
Nathaniel B. Ward, Esq. F.R.S. F.L.S.
Thomas Young, Esq.

were duly *elected* Members of the Royal Institution.

John Hall Gladstone, Esq., Ph. D. F.R.S.
Samuel Petrie, Esq.
Michael Wills, Esq.

were *admitted* Members of the Royal Institution.

MR. FARADAY gave an account of some recent researches by Dr. Schönbein on the action of temperature upon the physical condition of bodies as manifested by their changes of colour. That heat deepens the colour of many bodies is well known; thus, sulphur becomes more and more coloured as it is heated. Schönbein has shewn that the change does not cease at common temperatures, but that very cold sulphur is a colourless body. Even ink appears to be such a body; for diluted ink, being frozen, gives a dark coloured ice, and this by cooling to 40° below zero becomes colourless: it resumes its colour as it rises in temperature, and becomes dark before it ceases to be ice. Some bodies which are colourless at common temperatures acquire colour, either by heating or cooling; — thus, if an infusion of roses or dahlias, rendered colourless by sulphurous acid, be raised in temperature, it will become coloured, and will lose the colour again as it cools. Or if it be introduced into a glass tube, and frozen by a mixture of snow and salt, it first freezes into a white ice, and then at a lower temperature becomes beautifully coloured red, after which, if it be raised in temperature it first loses the colour, then thaws, and at last melts into a colourless fluid.

The following PRESENTS were announced, and the thanks of the Members returned for the same:—

FROM

*Airy, G. B. Esq. F.R.S. Astronomer-Royal (the Author)* — On the Eclipses of Agathocles, Thales, and Xerxes. (From Phil. Trans. Roy. Soc.) 4to. 1853.
*Ashburton, Lord (the Author)* — Address to the Elementary Schoolmasters assembled at Winchester, Dec. 16, 1853. 8vo. 1854.
*Astronomical Society, Royal* — Monthly Notices, Vol. XIV. No. 3. 8vo. 1853.
*Athenæum Club* — List of Members, &c. 1853.
*Bell, Jacob, Esq.* — Pharmaceutical Journal, March, 1854. 8vo.
*Boosey, Messrs. (the Publishers)* — The Musical World for Feb. 1854. 4to.
*British Architects, Royal Institute of* — Proceedings in Feb. 1854.
*Civil Engineers, Institution of* — Proceedings in Feb. 1854. 8vo.
*Cambridge Observatory, Syndicate* — Astronomical Observations made at Cambridge, by the Rev. James Challis. Vol. XVII. 4to. 1854.
*Editors* — The Medical Circular for Feb. 1854. 8vo.
The Athenæum for Feb. 1854. 4to.
The Practical Mechanic's Journal for March, 1854. 4to.
The Journal of Gas-Lighting, Feb. 1854. 4to.
The Mechanics' Magazine. Vol. LVII.—LIX. and continuation. 8vo. 1852-4.
*Faraday, Professor, D.C.L., F.R.S.*—
Geschichte der Prager Universität, von Wenzel Wladiwoj Tomek. 8vo. Prag, 1849.
Tomáse ze Stítného Knízky Sestery o Obecnych Vecech Krestanskych. 8vo. Praze, 1852.
Monatsbericht der Königl. Preussischen Akademie zu Berlin, Jan. 1854. 8vo.
Atti dell' Accademia Pontificia de' Lincei. Anno V. Sess. 2, 3, 4. 4to. Roma, 1853.
*Franklin Institute of Pennsylvania* — Journal, Vol. XXVII. Nos. 2. 8vo. 1854.
*Geographical Society, Royal* — Journal. Vol. XXIII. 8vo. 1853.
Index to Second Ten Volumes of the Journal. 8vo. 1853.
*Geological Society* — Journal. No. 37. 8vo. 1854.
*Graham, George, Esq. Registrar-General* — Weekly Reports of the Registrar-General. Feb. 1854. 8vo.
*Lovell, E. B. Esq. (the Editor)* —The Monthly Digest for Feb. 1854. 8vo.
*Lyne, T. Esq. (the Author)* — Tribunals of Commerce. 8vo. 1854.
*Novello, Messrs. (the Publishers)* — The Musical Times, March, 1854. 4to.
*Physicians, Royal College of* — Reports on Epidemic Cholera, by W. Baly, M.D. and W. W. Gull, M.D. 8vo. 1854.
*Prince, C. Leeson, Esq. (the Author)* — Results of a Meteorological Journal kept at Uckfield, Sussex, in 1853. Sheet.
*Royal Society of London* — Philosophical Transactions, Vol. CXLIII. Parts 2 and 3. 4to. 1853.
Proceedings, No. 101. 8vo. 1854.
List of Fellows. 4to. 1853.
*Society of Arts* — Journal, Feb. 1854. 8vo.
*Smith, Mr. J. Russell (the Publisher)* — The Retrospective Review. No. 6. 8vo. 1854.
"Who shall make the Law-makers? A Question, with Answer attempted." 8vo. 1854.
*Statistical Society* — Journal, Vol. XVII. Part 1. 8vo. 1854.
*Taylor, Rev. W., F.R.S. M.R.I* — The Flora of Yorkshire, by Henry Baines. 8vo. 1840.
*Vereins zur Beförderung des Gewerbfleisses in Preussen* — Verhandlungen, Sept.—Dec. 1853. 4to. Berlin.
*Wells, Thomas Spencer, Esq. M.R.I. (the Author)* — Practical Observations on Gout and its Complications. 16mo. 1854.

## WEEKLY EVENING MEETING,

Friday, March 10.

Right Hon. Baron Parke, Vice-President, in the Chair.

Charles Brooke, M.A., F.R.S.

SURGEON TO THE WESTMINSTER HOSPITAL.

### *On the Construction of the Compound Achromatic Microscope.*

Mr. Brooke stated his motive in giving the Lecture to be an observation frequently made, that many who are in possession of the best microscopes, either for the purpose of pursuing original investigations, or of seeking rational recreation in acquiring a knowledge of the structure of natural objects, do not develop the full power of their instruments, from a want of sufficient acquaintance with the principles on which the definition of objects depends.

After briefly adverting to the ordinary phenomena of reflection, the Lecturer illustrated those of refraction by a movable diagram, which readily explained the total reflection of a ray of light incident on the common surface of two media at an angle greater than the *critical* angle, corresponding to which the angle of refraction is 90°.

The aberration of rays reflected or refracted at a spherical surface was then alluded to; and although the reflectors employed in microscopes may be rendered free from spherical aberration by giving them an elliptic, and those of telescopes, a parabolic form, there is no practicable method at present known of constructing lenses otherwise than with spherical or plane surfaces: and from the difficulty of obtaining sufficiently perfect reflecting surfaces, and of preserving them when obtained, refracting microscopes are now almost universally employed.

Chromatic dispersion was then mentioned, and the usual mode of producing achromatism by the combination of various kinds of glass, which differ in their dispersive power, was illustrated by a combination of three prisms. The construction of achromatic object-glasses was next explained, as well as the nature of the aberration produced by the presence or absence of a plate of thin glass covering the object, and the mode of correcting it in object-glasses of high power, by varying the distance of the anterior from the posterior combinations, as first extensively applied in practice by Mr. A. Ross, and fully detailed in his article on the Microscope, in the Penny Cyclopædia.

The angle of aperture of object-glasses was then explained, and the power of those of large angular aperture in developing the

structure of certain test objects, such as the siliceous shells of diatomaceæ, was explained to be totally distinct from the mere increase of the amount of light transmitted. Mr. Brooke offered an hypothesis as to the structure of these objects, from which it would follow that that structure would be rendered visible by oblique rays *alone*, and the necessary degree of obliquity would depend on the smallness of the elevations on the undulating surface of the shell. This view was thus shewn to be highly probable; a specimen of the Pleurosigma formosum (first found by Mr. Brooke at Walton-on-the-Naze) was viewed under a half inch object-glass by Ross, and an achromatic eye-piece of high power, (which was stated to be unquestionably superior to a deep Huygenian eye-piece); when an opaque disc was interposed between the object and the centre of the object-glass, which cut off a large portion of the central rays, the diagonal rows of dots were still distinctly visible; but when the marginal rays were stopped out by a diaphragm, although a much larger quantity of light was admitted than in the former case, the markings were entirely lost.

In order to render visible the more difficult objects of this class, glasses of large angle of aperture have been constructed, but their employment is much limited, owing to the greatly increased difficulty of correcting the aberrations, under any given circumstances of the transmitted pencil of light, and consequently the small amount of correction, that is, of adaptation to altered circumstances, that they admit of. From investigations which he knew to be in progress, the Lecturer expressed a hope that by due adjustments of the illuminating pencil, the most difficult test-objects would be rendered equally visible under object-glasses of moderate aperture, which are much more generally useful.

Mr. Brooke then alluded to the preposterous reputed angle of aperture of certain foreign object-glasses, viz. 172°, and explained the fallacy of the ordinary method of determining that angle; which consists in viewing through a microscope the light of a lamp placed at a few feet distance, and moving either the light or the microscope, so as to traverse the entire angular distance through which the light is visible. In this method the course of the rays is contrary to their usual course, and oblique pencils may be brought to an imperfect focus at the back of the object-glass, and produce a glare of light, but which meet at a greater angle than the extreme rays that can enter the object glass *from the field of view*, and which consequently are the extreme available rays.

A very perfect instrument for measuring the angle of aperture, designed by Mr. Gillett, was then explained: this consists of two microscopes, the optical axes of which may be adjusted to coincidence. One of these is attached horizontally to the traversing

arm of a horizontal graduated circle, and is adjusted so that the point of a needle, made to coincide with the axis of motion of the movable arm, may be in focus and in the centre of the field of view. The other microscope, to which the object-glass to be examined is attached, is fixed, and so adjusted, that the point of the same needle may be in focus in the centre of its field. The eye-piece of the latter is then removed, and a cap with a very small aperture is substituted, close to which a lamp is placed. It is evident that the rays transmitted by the aperture will pursue *the same course* in reaching the point of the needle, as the visual rays from that point to the eye, but *in a contrary direction*, and being transmitted through the movable microscope, the eye will perceive an image of the bright spot of light throughout that angular space that represents the true aperture of the object-glass examined. The applications of this instrument in the construction of object-glasses are too numerous to be here detailed: amongst the most obvious of which may be mentioned the ready means it presents of determining the nature, and measuring the amount of the aberration in any given optical combination.

The important subject of Illumination was then so far considered as the short space of time allotted to the discourse would permit. It may be taken as an axiom that in the illumination of transparent objects, the amount of definition will depend on the accuracy with which the illuminating rays converge upon the several points of an object; consequently the source of light and the field of view must be the *conjugate foci* of the illuminator, of which an achromatic combination, similar to an object-glass, is the best form, and the common mirror usually employed is probably the worst, inasmuch as in a pencil of rays obliquely reflected at a spherical surface, no focal point exists.

The first compound microscopes on record, as those of P. Bonnani, about 1697, which was placed horizontally, and that of J. Marshall in the beginning of the eighteenth century, which was vertical, were furnished with central condensers, but in later years the perfection of the illuminating apparatus has by no means kept pace with that of the ocular portion of the microscope, though scarcely of less importance, in attaining the utmost practicable perfection in the vision of microscopic objects.

The advantages of employing an achromatic condenser were first pointed out by Dujardin, since which time an object-glass has been frequently, but inconveniently employed, and more recently achromatic illuminators have been constructed by most of our instrument-makers.

Some years since Mr. Gillett was led by observation to appreciate the importance of controlling not merely the *quantity of light*, which may be effected by a diaphragm placed any where between the source of light and the object, but the *angle of aperture of the*

*illuminating pencil*, which can be effected only by a diaphragm placed immediately behind the achromatic illuminating combination. An elastic diaphragm, or *artificial pupil* as it might be called, was first proposed by Mr. Brooke, which was shewn to answer very well in a large model, and produced a remarkable semblance of vital contractility; but mechanical difficulties interfered with its application, and the revolving diaphragm in the instrument, now well known as Gillett's condenser, was substituted.*

When the rays of light converging on the field of view meet at a greater angle than that of the extreme rays that can enter the object-glass, the dark-ground illumination is produced, in which the objects are seen in strong lines of light on a dark ground; this is best suited to objects having a well-marked outline, such as the spicula of sponge, or the shells of the polygastrica. This may be effected either by Wenham's truncated parabolic reflector, or by a central opaque stop in Gillett's condenser.

The value of this kind of illumination in certain cases was shewn by its effect in rendering visible the persistent cell-walls in a specimen of hard vegetable tissue, a section of a plum-stone, which could hardly be distinguished by the ordinary, or bright-ground illumination.

A white cloud brightly illuminated by the sun has long been recognised as the best source of illumination, but as this is not often obtainable, the light of a lamp thrown upon a flat surface of plaister of Paris, or powdered carbonate of soda, has been used as a substitute. A flat surface of white enamel finely ground, but not polished, has been used with advantage by Mr. Gillett, as the surface can always be rendered perfectly clear by a little soap and water. By either of these means the glare resulting from throwing the unmodified light of a lamp on the object is completely obviated.

The effect of glare or diffused light in interfering with the vision of an object was illustrated by reference to an experiment of Professor Faraday's, in which a screen of gauze partially blackened is held in front of a printed placard or diagram; the diffused light reflected from the white gauze considerably obscures the object, which is scarcely interfered with by the blackened portion.

The influence of illumination upon definition was rendered very evident by placing the two halves of a fly's tongue, similarly mounted, under two microscopes having precisely similar object-glasses and eye-pieces; the one was carefully illuminated by an achromatic condenser, and artificial white cloud; the other, by the light of a similar lamp reflected from a concave mirror: the dif-

* A description of this very useful apparatus has been recently published in the "Elements of Natural Philosophy," by Golding Bird and Charles Brooke.

ference was so conspicuous, that some were inclined to doubt the identity of the objects.

The whole subject of the illumination of opaque objects, as well as that of oblique illumination, by Kingsley's condenser, and by the prisms of Nachet and Amici, of which diagrams were exhibited, and by other means, was unavoidably omitted

Microscopes by the three leading makers were placed on the table; between the optical parts of which Mr. Brooke declined the task of drawing any invidious distinctions. He however expressed a preference for the stand of Mr. Ross, on account of its having a secondary stage with rectangular adjustments, and a rotatory movement by which any illumimating apparatus may be made to revolve after its axis has been brought to coincide with that of the microscope.

A stand by Mr. Ladd was also exhibited, in which the various movements are effected with great smoothness, and without "loss of time," by means of wrapping chains: also the ingenious apparatus of Mr. Highley, for obtaining photographs of microscopic objects, of which time did not admit of any explanation being offered.

In a curious and complicated microscope, the property of Prof. Quekett, constructed about the middle of the last century by Benjamin Martin, might be noticed several points of construction, that have been introduced as recent improvements.

[C. B.]

[FOR THE USE OF MEMBERS.]

# Royal Institution of Great Britain.

1854.

## WEEKLY EVENING MEETING,

Friday, March 17.

SIR JOHN P. BOILEAU, Bart. F.R.S. F.S.A. Vice-President, in the Chair.

STEPHEN H. WARD, M.D. LOND.

### *On the Growth of Plants in Closely-glazed Cases.*

HAVING glanced at the various causes, the soot, dust, deleterious gases, and cold, drying winds, which interfere with the growth of plants in cities and towns, the Lecturer noticed the incident which, in the year 1829, led Mr. Ward to discover a remedy in the "closely-glazed cases."

In the principle and construction of the Wardian cases there is no mystery whatever. The principle is, the exclusion from the plants of deleterious influences and agents, the admission and retention of those that are necessary; and it is realized in a common stoppered bottle, a garden-pot, or a pan covered with a bell-glass, or a trough surmounted by a glazed frame-work. Nothing can be more erroneous than the notion which has been entertained, even by educated persons, that these cases are hermetically sealed, and that the plants live without air. Closely-glazed the cases are and should be, but not closed. Closed only to adverse, open to genial and indispensable influences. Excluding soot and dust and the deleterious gases entangled in smoke, guarding against sudden changes of temperature and drying winds, preserving the nutritious aqueous vapour, admitting light, and subtly, but certainly in obedience to the diffusion law, such renewal of air as is required by the plants.

The construction of a case is very simple and is easily effected. The trough may be made of any material, wood tarred within, earthenware, or zinc; the last being perhaps preferable. To this a bell-glass or glazed frame-work is to be nicely adapted; and, supposing that ferns are to be grown in the case, the mode of arrangement is as follows. Into the bottom of the trough are thrown pieces of stone, potsherds, &c.; upon this a mixture of peat-mould and loam up to the level of the trough, and on the surface any artificial elevation or picturesque rock-work. The ferns are then planted, the mould is well saturated with water, the glass

covering is fitted on, and the case placed in a situation where it may be exposed to a due amount of light, but for ferns, not to the full force of the sun's rays. For the drainage of superfluous water, it is necessary either to have apertures perforated in the bottom of the case, or, what is better, a depression in a corner from which such water may be removed by means of a sponge or syringe. In a case so arranged, the several natural conditions of plants are fully realized. The closely-fitting glass covering, while it excludes soot and dust, admits freely the light which is essential to the vigorous and healthful growth of plants, since without it they are not duly nourished, and grow devoid of odour and colour, sickly and unattractive in aspect. In the next place, the water with which the mould has been saturated, and without which neither seeds nor plants can develop or grow, is retained or escapes only in inappreciable quantities. Exhaling from the leaves and rising from the mould in the form of vapour, it becomes condensed on the surface of the glass in the form of small beaded drops which, coalescing, form streamlets that course down the side of the glass: the water is again absorbed by the mould, evaporated and condensed, and so keeps up a ceaseless circulation. The plants in a bottle which was exhibited had had no fresh water for nineteen years. Again, the perfect tranquillity of the air within the case enables the plants to bear both higher and lower degrees of temperature than they would do if exposed, because the protective vapour which surrounds them is not carried off. For this reason, a glass shade placed over cut flowers preserves them in a state of freshness for a considerable period. And, lastly, with regard to the admission of air. The case is not, and cannot be hermetically sealed or air tight. If it were, the first change in the relative temperature of the air within and without would result in the fracture of the glass. Change of air is effected very subtly, but must ever be going on in obedience to the diffusion law by which gases of different density become intimately blended; rising against the attraction of gravitation, passing through bladder and other membranes, and through barriers more complete than a glazed frame-work which is only nicely adapted to, not amalgamated with the case below.

While the different natural conditions are realized in one of these cases, they may be so modified as to suit the requirements of different kinds of plants. Ferns generally require a peaty mould, a humid atmosphere, and a moderate supply of light. As an instance of the perfection to which they will attain under this plan, may be noticed the success which has attended one of the most delicate, the Trichomanes speciosum. In the first experiment made with this, the fronds attained a size one fourth larger than native specimens either from Killarney or Teneriffe; and Mr. Callwell of Dublin has a plant which, remarkably slow as this fern is of growth, has produced in nine years three hundred fronds varying

in length from fourteen to twenty inches and a half. For flowering plants a more loamy soil is desirable, less moisture, a greater volume of air, and more or less exposure to the direct rays of the sun. But that they can be grown just as successfully as ferns is proved by the fact, that in the most smoke-charged atmosphere in the east of London, various spring flowers, fairy roses, &c. flowered, year after year, most luxuriantly, and remained in flower much longer than they do in our country gardens. For cactuses and succulent plants a dry sandy soil and direct sunlight are necessary. In short, the isolating glass covering enables us to obtain in these cases a climate within a climate, a little world within a world.

As regards design and dimensions, the cases may be varied to an indefinite extent. [Attention was here directed to the suggestive diagrams by E. W. Cooke, A. R. A.] It is desirable, in order to obtain a light and elegant appearance, that the trough should be shallow; increase of surface for the growth of plants being gained by some picturesque central elevation. For hints, however, in reference to this part of the subject Mr. Ward's little work * may be advantageously consulted.

The applications of these cases are various. The first and one of the most important is to the growth of plants in towns and cities; the citizen being enabled by them to enjoy the constant prospect of ferns and flowers, instead of looking out upon dingy tenements. They may not only be used as beautiful window-blinds; but a case of larger dimensions may be built out from a library or breakfast parlour, in which, by aid of moderate artificial heat during the winter, plants of warmer climates may be associated with those of this country. Not only may they be made to occupy window-recesses, but the spaces between and at the sides of windows, which under the present system of domestic architecture are usually so dark as to be unavailable for pictures or any other purpose, might be converted into Wardian cases, in which plants and animals might be associated. Such an arrangement would be the source of constant interest to the mind, and would, at the same time, render the room lighter and consequently healthier and more cheerful. Modifications of the plan such as have just been suggested are, however, adapted only for those of tolerably ample means. Now the cultivation of plants has ever been peculiarly the poor man's luxury. To the taste and love for nature which he often exhibits, these cases may be made to minister; for they may be constructed at a very trifling expense, and the plants that would flourish in them, the primrose and anemone in spring, the wood-sorrel, the pimpernel, the common ivy which may be trailed over any part of the case, and the commoner kinds of fern may

* On the Growth of Plants in closely-glazed cases, by N. B. Ward, F. R. S. published by Van Voorst, Second Edition.

be procured by any one in a long walk or a very short railway ride out of London.

The Lecturer, in the next place, alluded to the application of the "cases" in promoting what he termed the "æsthetics" of the sick-room; and showed how important it was, in the treatment of chronic diseases and during the period of convalescence from others, to endeavour to dissipate morbid feelings and divert attention from still lingering symptoms by the cheering presence of things of beauty. In the chamber of the invalid, these cases presented an advantage over plants exposed in the ordinary way, because they confined those exhalations from flowers, which, agreeable as they may be to sense, are frequently prejudicial to the patient. At the suggestion of Mr. Burch, the resident medical officer of the London Hospital, some money had been collected for the construction of cases to be placed in the wards of that hospital.

In the conveyance of useful plants from one country to another, the plan has been of signal benefit to mankind. Formerly plants were packed in moss in boxes, or allowed to grow during the voyage, and, in consequence, a large proportion of them died. Now, the same arrangement which protected them from noxious influences in large towns, was found available in preserving the plants during long voyages from the salt spray and rough winds, from extremes of heat and cold, in admitting the light, and retaining the water which, on ship-board, is often a valuable commodity. In 1833 two cases, filled with British plants, were entrusted to Captain Mallard, who engaged to follow out directions, and take them with him to Sydney. When they arrived, after four or five months, at their place of destination, the plants were in full health, and a primrose which was in flower created no little sensation among the colonists. They were refilled with Australian plants, which reached England in perfectly good condition, and some of which had never been seen alive before in this country. From this time the plan became gradually adopted, in this and other countries, for the transport of plants. One or two examples will show the benefit it has conferred in this respect. The late Mr. Williams, the Missionary, on leaving this country in 1839 took with him a plant of banana, so important in the food which it furnishes to man, and introduced it into one or two of the Navigator Islands, where it was previously unknown. Mr. Fortune conveyed twenty thousand tea-plants in these cases in safety and perfect health from Shanghae to the Himalayas. Some of the finest palms that now decorate our large conservatories could not have been brought over to this country, but for Mr. Ward's invention; for even the seeds of these plants, in consequence of the oily matter which they contain, become decomposed when brought over in the ordinary way. They are now placed in the mould in a closed case; germination takes place during the voyage, and the young palm is found to be developed on arrival at the place

of destination. Sir W. Hooker bears ample testimony to the success of the plan, and states that in about four years nearly three thousand plants have been despatched to different parts of the world. When Captain M'Clintock left for the Arctic regions, a case containing British plants was entrusted to him, and, when last heard of, the plants had passed successfully through one polar winter.

Having glanced at the various philosophical purposes to which these cases may be applied, such as observations upon the habits of plants in an undisturbed atmosphere, the value of different moulds, and the action of the several vital stimuli, and having exhibited a plant of Linaria Cymballaria in illustration of the effects produced by deficient light, the Lecturer proceeded to notice the application to animals and man.

Philosophers have long been aware of the influence exerted by plants in counterbalancing the effects of animal respiration. Towards the end of the last century, Lavoisier led the way in determining what has been happily called "nature's balance," by showing the exact changes produced in the atmosphere by the respiration of animals. Priestley, soon after, proved by experiments with growing plants in air that had been vitiated by respiration and combustion, that they restored air so vitiated to its original purity. Senebier demonstrated the precise action exerted by plants in decomposing carbonic acid and fixing the carbon and liberating the oxygen, and that this takes place in water as well as air. Boussingault further proved that plants decompose water, and, from this, furnish another source of oxygen to air that has been deteriorated by animal life. Now, these counterbalancing actions of animal and vegetable life which are ever going on in the world without, and which are among the greatest marvels in the economy of Nature, may be realised most completely in one of these cases. Mr. Ward felt this, and accordingly in 1841 established in his largest fern-house, in a capacious earthenware vessel given to him by Mr. Alfred White, an aquarium for fish and plants. In this vessel, which contained twenty gallons of water and which he surrounded with rock-work raised several feet above its margin, he placed gold and silver fish in company with several aquatic plants, viz. Valisneria spiralis, Pontederia crassipes, Pistia stratiotes, and Papyrus elegans. In this miniature lake, the water of which was never changed, but kept in a constantly pure state by the action of the associated plants, the animals lived in a healthy condition for many years. This aquarium or vivarium soon gave the hint to Mr. Bowerbank who procured a large glass-jar, in which he placed stickle-backs, minnows, and snails, with plants of Valisneria, and covered in the jar with a piece of glass. Mr. Mitchell of the Zoological Society states that the jar just noticed, gave him the suggestion for the interesting vivaria at the Gardens. Aquaria in open bottles would seem to have been ornaments of the philosopher's study nearly a hundred years ago, as a coloured illustration in a work by Ledermüller, published in 1763 will prove. All that Mr. Ward claims

credit for, is the having introduced them into his closed cases, and depended for success entirely upon the counterbalancing actions of animal and vegetable life. The individual to whom is due the merit of having introduced marine vivaria into London is Mrs. Thynne. Having procured some living madrepores when at Torquay in the autumn of 1846, she placed them in some sea-water in a bottle covered with a bladder, and brought them safely to town. They were then transferred to two glass bowls, the sea-water being kept aerated by being daily poured backwards and forwards, and being, moreover, periodically renewed by a fresh supply from the coast. In the spring of 1847, Mrs. Thynne sent for some pieces of rock, shells, &c. to which living sea-weeds were attached, and subsequently depended upon the action of these for the purification of the water. For the removal of the confervæ which cover fresh-water aquatic plants, fresh-water snails are very serviceable. They are recommended to be introduced into vivaria for this purpose, in the number of the Microscopical Journal for Sept. 2, 1841, and, prior to that time, were used by Mr. Cornelius Varley.

By considerably increasing the volume of air, and introducing plants of high purifying action, there can be little doubt that these cases may be applied to the higher animals and even to man. Medical men have long felt the want of buildings, in which they might imitate the climate of any country, and adapt it to the necessities of the patient. In the early part of the present century, one or two physicians paid particular attention to the maintenance of equable temperature in the rooms of consumptive patients, through the aid of German stoves and what was then known of the principles of ventilation; and Dr. Arnott, in his Elements of Physics published more than twenty years back, describes a contrivance for the same purpose. From Mr. Ward, however, emanated the suggestion for the construction of a Sanatorium upon philosophical principles. His views were first brought before the public in the lecture delivered by Professor Faraday in April, 1838, and are clearly laid down in the first edition of his work, "The Growth of Plants, &c." published in 1842. Those who are acquainted with the means by which M. Payerne and his crew contrived to remain for twenty-four hours in a submarine vessel under the Seine, will feel, that, whatever may be the difficulties in the erection and renewal of air of such a building, they are not insurmountable. Sir J. Paxton's design for a Sanatorium in connexion with the Hospital for Consumption at Victoria Park, would seem to realize the sort of edifice proposed by Mr. Ward.

[S. H. W.]

## WEEKLY EVENING MEETING,

Friday, March 24.

William Wilberforce Bird, Esq., Vice-President, in the Chair.

Edwin Lankester, M.D., F.R.S.

### *On the distinctions supposed to limit the Vegetable and Animal Kingdoms.*

In commencing, the Lecturer made some general remarks on classification, and pointed out the importance of accurate definitions in order to constitute the classes, families, genera, and species of the naturalist. The importance of defining species was greater than that of larger groups, because these were composed of species. As genera were collections of species, and families collections of genera, so the animal and vegetable kingdoms were but collections of species. The difficulty in distinguishing between the animal and vegetable kingdoms consisted in our imperfect knowledge of the characters of species which existed on what might be called the limits of the two kingdoms. The history of the attempts at defining animals and plants, for systematic purposes, would afford the best idea of the nature of these difficulties. The definition of Linnæus, that minerals grow, plants grow and live, animals grow, live, and feel, was first examined. In order to apply this definition, the terms growth, life, and feeling, required explanation. *Growth* simply indicated increase. The term *life* could not be defined in such a manner as to render it inapplicable to the physical phenomena of the inorganic world and at the same time embrace the lowest forms of organised beings. *Feeling* could not be defined so as to separate the movements evinced by so many members of the vegetable kingdom on the application of external stimulants, as the movements of the leaves of the sensitive plant, of the *Dionæa muscipula*, the stamens of the *barberry*, and the closing and unfolding of flowers from those of the animal kingdom. Such were the distinctions attempted to be made by one who disregarded the use of the microscope.

One of the most obvious distinctions between the organic and inorganic kingdoms was the presence of the cell in the former. Under some circumstances it was not easy to detect the cell, as in certain fossils, and sometimes inorganic matters assumed a cellular form.

Another distinction adopted by naturalists, even since the general introduction of the microscope into natural history inquiries, was, that animals moved, whilst plants were fixed. This distinction, though applicable to the higher forms of plants and animals, was

more than ever inapplicable to the organisms which required the microscope to detect their existence. Recent researches had shewn that the motile tissues in animals were composed of the same substance that was found to be present in the cells of all plants, and which under the names of nucleus, cytoblast, primordial utricle, and endoplast, had been recognised by all vegetable physiologists. This substance, composed of protein, was as actively motile in the plant as the animal. It was this substance which gave motility to the cells of *Protococcus*, the fibres of *Oscillaria*, the spores of various *confervæ* and *fungi*, and probably also to all other movements observed amongst plants.

When cilia were originally discovered as the agents of movement in infusoria, and upon the internal organs of higher animals, they were regarded as characteristic of animal life. These organs were now known to be present in the zoospores of various confervæ, and were the active agents of movement in the *Volvox globator*, of whose vegetable nature there could be little doubt since the researches of Williamson and Busk.

The possession of what were called eye-spots in doubtful organisms had been brought forward to decide the animality of these beings. Such eye-spots were present as red points in certain stages of the growth of *Volvox*, and other undoubtedly vegetable organisms, and according to Henfrey were due to the relation of the contents of the cell to light, and were in no way the agents of vision in the cells in which they are found.

The definition of Aristotle, that animals possessed a mouth, whilst plants had none, had been recently revived; and of all merely structural characters, it was the one best suited to the purpose of the naturalist. Until recently the exceptions to this definition were numerous; but since the botanist had claimed so large a number of mouthless infusoria, as the *Diatomaceæ*, *Desmideæ*, and *Volvocineæ*, it was more than ever applicable. There were, however, certain exceptions; and these were found in the *Foraminifera*, the *Difflugiæ*, and other low organisms which had no permanent mouth. Some of these have the power of forming a temporary sac for the purposes of digestion.

Chemistry had from time to time offered its aid to the naturalist. At one time the possession of *cellulose* by the vegetable kingdom was considered distinctive, and the ready application of iodine and sulphuric acid as the test of its presence rendered it an easily ascertainable diagnostic mark. It had, however, been recently detected by Smid in the Ascidian mollusca, by Thwaites in the *Acaridæ*, and by *Virchow* in the brain and spleen of man.

Another substance, *chlorophyll*, appeared at one time, to pronounce the presence of plants; but it had been found by Schulz in *Hydra*, *Turbellaria*, *Vortex*, *Mesostomum*, *Stentor*, *Bursaria* and other decidedly animal organisms.

Starch was another vegetable product, easily detected by iodine,

whose universal presence in the plant seemed to offer the best practical chemical test; but Busk and other observers had recently detected this substance in the brain of man, and there was reason to suppose that starch might be very generally present in the animal kingdom.

It was thus seen that no one point in structure or chemical composition could furnish a means of distinction. A physiological point of much interest and importance had principally determined a certain number of botanists in claiming the *Diatomaceæ* and *Desmideæ* as plants. In certain confervæ it had been observed, that previous to the production of the zoospore, two contiguous cells united, and each contributed its contents to form the germinating spore. This process was observed by Ralf and others in *Desmideæ*, and subsequently by Thwaites in the *Diatomaceæ*. In addition to this point these families exhibit other relations with the vegetable kingdom.

Whatever might be the difficulties presented in any individual case in the application of all or any of the before-mentioned distinctions, there was evidently a great antagonism or polarity exhibited by the animal and vegetable kingdoms when viewed as a whole. They were mutually dependent, attained the same ends in their growth and organization, but by contrary means. The great function of the animal tissues was the absorption of oxygen, and the disengagement of carbonic acid. The great function of the vegetable tissues was the absorption of carbonic acid and the disengagement of oxygen. The processes in the history of the life of the two kingdoms in which these distinctive functions appeared to be reversed, were not exceptions to the law, but were due to other agencies than those connected with the essential life of the plant or the animal. Thus carbonic acid was given out by plants at night, during fructification and germination. In the first instance, the gas given out was that which had been taken up during the day, and was not decomposed by the agency of light. In the latter instances a process of exudation took place in which the contents of the cells were undergoing change independent of the life of the plant. The germ during the growth of its cells absorbed carbonic acid and gave out oxygen, as in the growth of all other vegetable cells. The development of the carbonic acid arose from the decomposition of the starch and the sugar of the albumen of the seed. In the cases where animals had been found to give off oxygen, it was doubtful as to whether plants were not present or even mistaken for animalcules.

The composition of a series of vegetable and animal products was exhibited; and attention was drawn to the fact, that in all cases the vegetable compounds were formed from carbonic acid and water, or from carbonic acid, water, and ammonia, by the loss of oxygen. Acetic acid was referred to as an exceptional instance; but it was shewn that it was more probable, where acetic acid occurred as the result of vegetation, that it occurred as the result of deoxidation

than of a process of fermentation in which alcohol was developed and subsequently oxidised. An exception was also referred to in the animal kingdom in which fat is supposed to be formed by the deoxidation of sugar; but attention was drawn to the fact that this process admitted of another explanation, not opposed to the physiologico-chemical distinction pointed out.

These processes were further shewn to be connected with the relations existing between the animal and vegetable kingdoms. The plant was produced from mineral compounds—carbonic acid, water, and ammonia,—the substances out of which the animal was formed; and no instance was known of the animal appropriating and forming organic substances out of these compounds. This was the distinguishing feature of the life of the plant, and the liberation of oxygen gas its most constant result. The appropriation of substances thus formed, and the uniting them once more to oxygen gas, was the distinguishing feature of animal life, and the formation of carbonic acid gas its most constant result. Minor changes occurred; but these were the grand distinguishing features of the two kingdoms, the recognition of which by structure, function, or results could alone enable us to distinguish between plants and animals.

[E. L.]

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## WEEKLY EVENING MEETING,

Friday, March 31.

Col. Philip J. Yorke, F.R.S. President of the Chemical Society, in the Chair.

John Hall Gladstone, Esq., Ph. D., F.R.S.

*On Chemical Affinity among Substances in Solution.*

An historical sketch of the development of the ideas of chemists concerning "Affinity" was first given. The dogma of Hippocrates that "Like combines only with like," was shewn to be superseded by the view of Glauber and others, that unlike substances combine most readily: and that where two bodies have an affinity *for* one another, it is a sign that they have *no* affinity *with* one another. The views of Newton and Boyle in reference to the different degrees of strength of affinity were then considered, and particular attention was directed to the doctrine of Bergmann, that when a decomposition takes place by means of the greater elective attraction of a third body, that decomposition is complete. In opposition to this, Berthollet contended that in all such cases of composition, or decomposition, there takes place a partition of the

base, or subject of the combination, between the two bodies whose actions are opposed; and that the proportions of this partition are determined, not solely by the difference of energy in the affinities, but also by the difference of the quantities of the bodies,—by their physical condition,—and by that of the combinations capable of being generated. These views did not meet with a favourable reception at the time of their promulgation; and the attention of chemists had been drawn away from the subject until within these last few years, when Malaguti, Bunsen, Debus, and Williamson, have published investigations bearing upon the point. The Lecturer then stated that before any of these papers had appeared, he had been thinking of and performing some experiments upon the subject in question, and that he was still continuing them.

After a few experiments illustrative of "Chemical combination" and of "Elective Affinity," others were introduced to show how easily this latter phenomenon was affected by circumstances. Thus ammonia will displace alumina from a solution of the sulphate, but on the other hand, alumina will displace ammonia when heated with the solid sulphate of that volatile base; whilst if solutions of chloride of aluminum and sulphate of ammonia be mixed and evaporated, crystals of the double sulphate, ammonia-alum, will appear. There were on the table two white salts; the one had been carbonate of baryta, but by boiling with excess of sulphate of potash, it had been converted into the sulphate; the other had been sulphate of baryta, but by long continued boiling with much carbonate of potash, it had suffered the opposite change into the carbonate. The Lecturer then stated that so great is the influence exerted by these various circumstances, that some have doubted whether there be a true "elective affinity;" he however believed that after making every allowance for known causes there is still a residuary phenomenon to which that name is the most appropriate. Allowing then, with Bergmann, that relative degrees of affinity exist, the question arises:—Is Berthollet's law also correct? It is very difficult to arrive at a satisfactory answer, since it is almost impossible to eliminate other influences. Several reactions, however, were mentioned as tending to show that there is some truth in the law:—for instance, the solution of gold in hydrochloric acid upon the addition of nitrate of potash. The experiments of Bunsen on mixtures of carbonic oxide and hydrogen, exploded with a quantity of oxygen insufficient for complete combustion; and those of Debus on the precipitation of mixed hydrates of lime and baryta by carbonic acid, were explained; as also the remarkable fact noticed by both, that the resulting products were always in certain atomic proportions to one another. But in both these cases the first products of the chemical action are removed at once from the field: it is quite another case when they remain free to act and react on one another. Supposing they all remain in solution, the requisite is fulfilled; but how are we to know what has then taken place? Malaguti thought

to obtain an indication of this by mixing the aqueous solutions of two salts, one of which is soluble in alcohol, and the other is insoluble, and then pouring them into very strong alcohol, and analyzing the salts immediately thrown down. His results are tabulated; they are valuable, but to some extent open to objection on account of the disturbing influence of the alcohol. Some observations of Professor Graham, and others of Professor Williamson, as yet unpublished, were then spoken of, and the Lecturer proceeded to describe his own endeavours to arrive at a knowledge of the intimate constitution of a mixture of salts in solution by observing their physical·properties, especially colour.

If solutions of one equivalent of nitrate of iron, and a triple equivalent of sulphocyanide of potassium be mixed, a blood-red colour results owing to the formation of sulphocyanide of the sesquioxide of iron; the question arises—Has all the iron left the nitric acid to unite itself with the sulphocyanogen? It has not; for on the addition of equivalent after equivalent of sulphocyanide of potassium, a deeper red is constantly obtained. The arrangement by which this deepening of colour was quantitatively determined was explained, and imitated on the lecture table. The result was that even up to 375 equivalents, a regular increase was observed to take place, more rapidly at first than afterwards, which was exhibited to the eye by the results being projected as a curve. Again, as in the mixture of equal equivalents of the two salts, some iron still remains in combination with the nitric acid, a portion of the potassium must still remain united to the sulphocyanogen. Accordingly, the addition of more iron salt also gives a deeper colour. The curve expressing the results of this experiment was a regular continuation of the curve formerly mentioned; and neither of them exhibited any of those sudden transitions which the experiments of Bunsen and Debus present. Diagrams exhibiting curves of the gallate and meconate of iron were also exhibited. Various experiments were then performed, showing the alteration in the resulting colour upon any change of any of the elements in the primary experiment; for instance, the substitution of other acids for the nitric acid, or of other bases for the potash. On the addition of a colourless salt to a coloured one, there results a diminution of the colour greater than the mere dilution would have produced, as was exemplified in the cases of the red sulphocyanide of iron mixed with sulphate of potash, and of the scarlet bromide of gold mixed with chloride of potassium. The lecturer accordingly drew the conclusion that when two salts mix without precipitation or volatilization, the acids and bases frequently, if not universally, arrange themselves according to some definite proportion; and that this depends on the relative quantity of the two salts, as well as upon the proper affinities of the substances composing them. He was unable then to enter upon the influence of heat, or of dilution in certain cases, or to add any remarks connected with double salts, or with other metals, or upon certain practical applications of these views in chemical and physiological science.

The fact that we very frequently find the double decomposition of a salt to be *complete*, the *whole* of one of its constituents being precipitated, was shown to be easily explained on the principles of Berthollet. Thus, for instance, when chromate of potash and nitrate of silver are mixed, at the first moment a division will take place producing four salts, but one of these — the chromate of silver, is thrown down at once as a precipitate, and thus put out of the field of action. Another division of the acids with the bases must take place, producing of course more of the insoluble chromate, and so on till at length the whole of the silver is removed. And that this is really what does take place is rendered almost certain by the fact that wherever by an interchange of acids and bases a precipitate can be produced, that precipitate does form; and, if the substance be perfectly insoluble, the whole is thrown down; this occurring in opposition to all rules of "affinity," and to all tables that Bergmann, or any other chemist, ever did or could construct. The volatility of one of the products acts in the same manner as insolubility, as is exemplified in the decomposition of carbonates by any other acid. Crystallization also is but another phase of the same phenomenon. An experiment was exhibited in illustration of this. Dilute solutions of nitrate of lime, and sulphate of soda, were mixed at the ordinary temperature without producing any separation of solid matter; but they were so proportioned that upon heating the mixture, the crystallization of some sulphate of lime was determined, and when once this had commenced, it progressed rapidly; resembling in that respect the ordinary phenomena of precipitation. If in a double decomposition a far larger quantity of a sparingly soluble salt be produced at the first moment than the water can dissolve, the crystals will be formed rapidly and will accordingly be very small in size; but should there be formed at once only just sufficient to determine a separation in the solid form, the crystals will grow gradually, and will often attain a large size. This was exemplified on the mixture of nitrate of silver with the sulphates of copper and of potash respectively.

It is possible that the law of Berthollet may not be universally applicable; yet the present advanced state of science shows that not only is there, as Bergmann insisted, a true chemical affinity, that is— a preference of one substance to combine with a certain other substance instead of a third,—but, in a great number of instances at least, this substance will combine with both according to certain proportions, whenever the whole of the affinities can be brought into play at the same time.

[J. H. G.]

## GENERAL MONTHLY MEETING,

Monday, April 3, 1854.

WILLIAM POLE, ESQ., M.A., F.R.S., Treasurer and Vice-President, in the Chair.

The Rev. George Edward Biber, LL.D. was duly *elected* a Member of the Royal Institution.

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| George Clowes, Esq. | Hananel De Leon, M.D. |
| Col. Lothian Sheffield Dickson. | Barry Charles Knight, Esq. |

were duly *admitted* Members of the Royal Institution.

The Rev. JOHN BARLOW, Hon. Sec., R.I., reported that the following Arrangements had been made for the Lectures after Easter:

Seven Lectures on EBULLITION, COMBUSTION, and other Phenomena of HEAT. By JOHN TYNDALL, Ph. D., F.R.S., Prof. Nat. Phil. R.I. To commence on Tuesday, April 25th, 1854.

Seven Lectures on BOTANY. By MAXWELL T. MASTERS, Esq. of the Fielding Herbarium, Oxford. To commence on Thursday, April 27th, 1854.

Seven Lectures on EDUCATION. To commence on Saturday, April 29th, 1854, viz.

1. REV. W. WHEWELL, D.D., F.R.S., Master of Trin. Coll. Camb. —On the Influence of the History of Science upon Intellectual Education.
2. PROFESSOR FARADAY, D.C.L., F.R.S.—Observations on Mental Education.
3. ROBERT GORDON LATHAM, M.D., F.R.S.—On the Importance of the Study of Language as a branch of Education for all Classes.
4. CHARLES G. B. DAUBENY, M.D., F.R.S.—On the Importance of the Study of Chemistry as a branch of Education for all Classes.
5. PROFESSOR TYNDALL, F.R.S.—On the Importance of the Study of Physics as a branch of Education for all Classes.
6. JAMES PAGET, Esq., F.R.S.—On the Importance of the Study of Physiology as a branch of Education for all Classes.
7. W. B. HODGSON, Esq., LL.D.—On the Importance of the Study of Economic Science as a branch of Education for all Classes.

The following PRESENTS were announced, and the thanks of the Members returned for the same; —

FROM

*Astronomical Society, Royal* — Monthly Notices, Vol. XIV. No. 4. 8vo. 1853.

*Author* — "Where shall the New Law Courts be built?" By an Old Law Reformer. 8vo. 1854.

*Bell, Jacob, Esq.* — Pharmaceutical Journal, April, 1854. 8vo.

*Boosey, Messrs. (the Publishers)* — The Musical World for March, 1854. 4to.

*British Architects, Royal Institute of* — Proceedings in March, 1854.

*Brown, William, Esq., M.P. (the Author)* — Letter to Francis Shand, Esq. on the Decimal Coinage. 8vo. 1854.

*Chemical Society* — Quarterly Journal, Vol. VII. No. 1. 8vo. 1854.

*Civil Engineers, Institution of* — Proceedings in March, 1854. 8vo.

*Editors* — The Medical Circular for March, 1854. 8vo.
 The Athenæum for March, 1854. 4to.
 The Practical Mechanic's Journal for April, 1854. 4to.
 The Journal of Gas-Lighting, March, 1854. 4to.
 The Mechanics' Magazine, for March, 1854.

*Faraday, Professor, D.C.L., F.R.S. &c.* — Mémoires de l'Académie des Sciences de l'Institut de France. Tome XXIV. 4to. Paris, 1854.
 *Kaiserliche Akademie der Wissenschaften, Wien:* — Almanach: 4te Jahrgang. 16mo. 1854.
 *Philosophisch-Historische Classe:* — Sitzungsberichte. Band XI. Hefte 1, 2, 3. 8vo. 1853.
 Archiv für Kunde Œsterreichischer Geschichtsquellen, Band X. Heft 2; und Band XI. 8vo. 1853.
 Notizenblatt. (Beilage zum Archiv.) 1853. No. 1—20. 8vo.
 *Mathematisch-Naturwissenschaftliche Classe:* — Denkschriften. Band VI. 4to. 1853.
 Sitzungsberichte. Band XI. Hefte 1—4. 8vo. 1853.

*Franklin Institute of Pennsylvania* — Journal, Vol. XXVII. No. 3. 8vo. 1854.

*Graham, George, Esq. Registrar-General* — Weekly Reports of the Registrar-General for March, 1854. 8vo.

*Holdship, John, Esq., M.R.I.* — On the Plurality of Worlds; an Essay. 8vo. 1853.

*Leeds Philosophical Society* — Annual Report, 1852-3. 8vo.
 Reports of the Proceedings of the Geological and Polytechnic Society of the West Riding of York for 1852. 8vo. 1853.

*Lovell, E. B. Esq. (the Editor)* — The Monthly Digest, Annual Volume for 1853. and the Number for March, 1854. 8vo.
 The Common Law and Equity Reports, Part 9. 8vo. 1854.

*Novello, Messrs. (the Publishers)* — The Musical Times, April, 1854. 4to.

*Photographic Society* — Journal, No. 15. 8vo. 1854.

*Society of Arts* — Journal for March, 1854. 8vo.

*Sylvester, J. J. Esq., M.A., F.R.S. (the Author)* — On a Theory of the Syzygetic Relations of Two Rational Integral Functions. 4to. 1853.

*Twining, Thomas, Jun., Esq., M.R.I.* — Jahrbücher des Vereins für Naturkunde im Herzogthum Nassau. Achtes Heft. 8vo. Wiesbaden, 1852.

*Crampton, Mr.* — Specimen of Submarine Electric Telegraph Cable laid down in October, 1851 taken up about November, 1853.

## WEEKLY EVENING MEETING,

Friday, April 7, 1854.

Sir Charles Fellows, Vice-President, in the Chair.

Rev. J. Barlow, M.A., F.R.S., Vice-President, and Sec. R. I.

*On Silica and some of its applications to the Arts.*

Silica is one of the most abundant substances known. Quartz, common sand, &c. flint, chalcedony, opal, &c., and a variety of sand described by Mr. J. T. Way,* may respectively be taken as examples of crystallized and uncrystallized silica. Under all these forms silica is capable of combining with bases as an acid. Heat is however essentially necessary to effect this combination, a combination of which all the well known silicates, whether natural, as feldspar, mica, clay, &c., or artificial, as glass, slags, &c. are the results. The common forms of insoluble glass are produced by the union of silica with more than one base. But, when combined with an alkaline base only, silica forms a soluble glass, the degree of solubility of which depends on the proportion which the silicic acid bears to this alkaline base . . . . This soluble silicated alkali (or water-glass) may be prepared by various processes. If sand be used, 15 parts of fine sand, thoroughly incorporated with 8 parts of carbonate of soda, or with 10 of carbonate of potass, and one of charcoal fused in a furnace will produce a silicated alkali which is soluble in boiling water. Messrs. Ransomes obtain this silicated alkali by dissolving broken flints in a solution of caustic alkali at a temperature of 300° Fah.† And, more recently, Mr. Way has observed that the sand which he has described, will combine with caustic alkali at boiling heat, also producing a water-glass.

This water-glass has been applied to several important purposes, three of which were specially noticed.

I. *To protect building-stones from decay.* The stone surfaces of buildings, by being exposed to the action of the atmosphere, become liable to disintegration from various causes. Moisture is absorbed into their pores. The tendency of their particles to separate, in consequence of expansion and contraction, produced by alternation of temperature, is thus increased. Sulphurous acid is always present in the atmosphere of coal-burning cities, and cannot but corrode the calcareous and magnesian ingredients of oolites and dolomites.

* Quarterly Journal of Chemical Society, July 1, 1853, and Journal of Royal Agricultural Society, Vol. xiv. Part 1.

† Report of a communication made to the Royal Institution by Professor Faraday, May 26, 1848. *Vide* Athenæum, June 17th, 1848.

It is true that good stone resists these sources of injury for an indefinite time, but such a material is rarely obtained. As a preventive of destruction, whether arising from physical or chemical causes, it has been proposed to saturate the surfaces of the stones with a solution of the water-glass.

It is well known that the affinity of silica for alkali is so feeble that it may be separated from this base by the weakest acids, even by carbonic acid. According to the expectation of those who recommend the silication of stone, the carbonic acid of the atmosphere will set the silica free from the water-glass, and the silica, thus separated, will be deposited within the pores and around the particles of the stone. The points of contact of these particles will thus be enlarged, and a sort of glazing of insoluble silica will be formed, sufficient to protect the stone against the effects of moisture, &c. This cause of protection applies chiefly to sandstones. But wherever carbonate of lime or carbonate of magnesia enters notably into the composition of the building-stone, then an additional chemical action, also protective of the stone, is expected to take place between these carbonates and the water-glass. Kuhlmann remarks, "Toutes les fois que l'on met en contact un sel insoluble avec la dissolution d'un sel dont l'acide peut former avec la base du sel insoluble un sel plus insoluble encore, il y a échange; mais le plus souvent cet échange n'est que partiel."* In consequence of this "partial exchange" an insoluble salt of lime may be looked for whenever a solution of water-glass is made to act on the carbonate of lime or carbonate of magnesia existing in oolitic or dolomitic building-stones.

This expectation, however, has not been altogether sanctioned by experiment. A gentleman, eminently conversant with building materials,† immersed a piece of Caen-stone in a solution of silicate of potass in the month of January, 1849. This fragment, together with a portion of the block from which it had been separated, was placed on the roof of a building in order that it might be fully exposed to the action of atmosphere and climate. After five years the silicated and the unsilicated specimens were found to be both in the same condition, both being equally corroded. [These specimens were exhibited in the Theatre of the Institution.] But whatever ultimate results may ensue from this process, the immediate effects on the stone are remarkable. Two portions of Caen-stone were exhibited, one of which had been soaked in a solution of water-glass two months before. The surface of the unsilicated specimen was soft, readily abraded when brushed with water, and its calcareous ingredients dissolved in a weak solution of sulphurous acid. The silicated surface, on the other hand, was perceptibly hard, and resisted the action of water and of dilute acid when similarly applied.‡

* Expériences Chimiques et Agronomiques, p. 120.

† Charles H. Smith, Esq. one of the Authors of the "Report on the Selection of Stone for the Building of the New Houses of Parliament."

‡ Silliman's American Journal, January, 1854, contains a notice of the application of the water-glass to the decaying surfaces in the Cathedral of Nôtre Dame in Paris.

II. Another proposed use of the water-glass is that of ***hardening cements, mortars, &c.***, so as to render them impermeable by water.

Fourteen years since Anthon* of Prague proposed several applications of the water-glass. Among others he suggested the rendering mortars water-proof. He also suggests that this substance might be beneficially employed as a substitute for size in white-washing and staining walls. It was demonstrated by several experiments that carbonate of lime mixed up with a weak solution of water-glass, and applied as a whitewash to surfaces, was not washed off by sponging with water, and that common whitewash, laid on in the usual manner with size, was rendered equally adhesive when washed over with water-glass.

III. *The Stereochrome of Fuchs.*

The formation of an insoluble cement by means of the water-glass, whenever the carbonic acid of the atmosphere acts on this substance, or whenever it is brought in contact with a lime-salt, has been applied by Fuchs to a most important purpose. The stereochrome is essentially the process of fresco secco† invested with the capability of receiving and perpetuating works of the highest artistic character, and which may be executed on a vast scale.—Fuchs's method is as follows:‡—

" Clean and washed quartz-sand is mixed with the smallest quan- " tity of lime which will enable the plasterer to place it on the wall. " The surface is then taken off with an iron-scraper, in order to re- " move the layer formed in contact with the atmosphere; the wall " being still moist during this operation. The wall is then allowed " to dry; after drying it is just in the state in which it could be rubbed " off by the finger. The wall has now to be *fixed*, *i. e.* moistened with " water-glass.§ (An important point is not to use too much water- " glass in moistening the wall.) This operation is usually performed " with a brush. The wall must be left in such a condition as to " be capable of receiving colours when afterwards painted on. If, " as frequently happens, the wall has been too strongly fixed, the " surface has to be removed with pumice and to be fixed again. " Being fixed in this manner the wall is suffered to dry. Before " the painter begins, he moistens the part on which he purposes to " work with distilled-water, squirted on by a syringe. He then " paints: if he wishes to repaint any part, he moistens again. As

* Neuere Mittheilungen über die Nutzanwendung des Wasser-Glases, 1840. This subject has also been fully treated by Kuhlmann in his " Mémoire sur l'Intervention de la potasse ou de la soude dans la formation des chaux hydrauliques," &c. 1841. Expériences Chimiques et Agronomiques.

† Vide Eastlake's Materials for a History of Oil Painting, p. 142.

‡ These particulars were obtained by Dr. Hofmann from Mr. Echter. A stereochromic picture by Echter and a sample of the water-glass as prepared in Munich were also exhibited by Dr. Hofmann.

§ The composition of the specimen produced was

| | | Per cent. |
|---|---|---|
| | Silica | 23.21 |
| | Soda | 8.90 |
| [The specific gravity of the solution 3.81.] | Potass | 2.52 |

" soon as the picture is finished, it is syringed over with water-glass. " After the wall is dry, the syringing is continued as long as a wet " sponge can remove any of the colour. An efflorescence of car- " bonate of soda sometimes appears on the picture soon after its " completion. This may either be removed by syringing with " water, or may be left to the action of the atmosphere." Not to dwell on the obvious advantages possessed by the stereochrome over the real fresco, (such as its admitting of being retouched and its dispensing with joinings,) it appears that damp and atmospheric influences, notoriously destructive of real fresco, do not injure pictures executed by this process.

* The following crucial experiment was made on one of these pictures. It was suspended for twelve months in the open air, under the principal chimney of the New Museum at Berlin; " during that time it was exposed to sunshine, mist, snow, and rain," and nevertheless " retained its full brilliancy of colour."

The stereochrome has been adopted on a grand scale by Kaulbach in decorating the interior of the great national edifice at Berlin already alluded to. These decorations are now in progress, and will consist of historical pictures † (the dimensions of which are 21 feet in height and $24\frac{3}{4}$ in width), single colossal figures, friezes, arabesques, chiaro scuro, &c. On the effect of the three finished pictures, it has been remarked by one whose opinion is entitled to respect, that they have all the brilliancy and vigour of oil paintings, while there is the absence of that dazzling confusion which new oil paintings are apt to present, unless they are viewed in one direction, which the spectator has to seek for.

Mr. A. Church has suggested that if the surface of oolitic stones (such as Caen-stone) is found to be protected by the process already described, it might be used, as a natural *intonaco*, to receive coloured designs, &c. for exterior decorations; the painting would then be cemented to the stone by the action of the water-glass.

Mr. Church has also executed designs of leaves on a sort of terra cotta, prepared from a variety of Way's silica rock, consisting of 75 parts clay and 25 of soluble silica. This surface, after being hardened by heat, is very well adapted for receiving colours in the first instance, and for retaining them after silication.

[J. B.]

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* Communication from Mr. George Bunsen.

† Three of these pictures are finished: —

1. The Fall of Babel.
2. The Blüthe Griechenlands ('the golden age of Grecian art and poetry').
3. The Fall of Jerusalem (an engraving of this picture was exhibited by Mr. Ackerman,)—Two other compositions are drawn, *i. e.*
4. The Battle of the Huns.
5. The Crusaders' arrival before Jerusalem.
6. The subject not yet decided on. (Communication from Mr. G. Bunsen.)

## William Roxburgh, M.D., M.R.I.

### *On the Cartesian Barometer.*

[The following remarks have been supplied by Dr. Roxburgh in relation to a barometer constructed by him and exhibited on this and several preceding evenings.]

Soon after the discovery of the variations in height of the barometer, Descartes proposed the following mode of rendering them more conspicuous, almost as much so as they are in one filled with water alone. He suggested that two tubes should be joined to the opposite ends of a short wide cylinder, so as to form one straight tube, which, being closed at one end, was to be filled with pure water and mercury in such proportions as to allow of the two fluids at all pressures meeting in the cylinder. In this, the Cartesian barometer, the pressure of the atmosphere is balanced by the water and mercury conjointly; but the variations of pressure are indicated chiefly by movements of the water, as the level of the mercury varies little in consequence of the large area of the cylinder. The movements of the water and mercury are to each other inversely as the areas of the tube and cylinder. The scale is that of the common barometer enlarged, as in the wheel barometer; when, therefore, the movements are said to amount to so many hundredths of an inch, it is to be understood as meaning that they are equal in value to that height of mercury. The scale can be enlarged so as to render movements of $\frac{1}{400}$th of an inch visible to the unassisted eye.

The only records of this instrument that I have seen state that the air contained in the water is given off when the pressure is removed, and so renders its indications incorrect; also that this imperfection is irremediable. This depression, amounting in one year, in my first experiment, to only ·02 of an inch, has led me to suppose that the depression which caused the plan to be set aside was owing to the force of vapour, which was not so well understood at that time as at present; and as many variations of pressure are easily seen in this barometer, which would escape notice in the mercurial one, and if not attended to give rise to error, I think it will prove a valuable addition to a standard barometer, though never a substitute for one.

In hopes of getting rid of the air, and of lessening the correction required for the force of vapour, I tried several fluids in place of pure water. Among these was oil of turpentine; this caused a rapid evolution of gas and blackening of the mercury, and depressed the column several inches in a few minutes. A

saturated solution of muriate of soda seemed at first more successful, but in a short time the column became depressed, and this depression continuing to increase at a regular rate, the tube was emptied, when it was found that the salt having crystallized between the mercury and the glass, had so allowed the air to enter.

A solution of muriate of lime, not being crystallizable, was next tried; and this seems to stand best, as yet having sunk in 2½ years only ·03 of an inch, the greater part of this depression having occurred in the first few months, giving rise to the surmise that the air which has caused it was left in at the time of filling, and has not crept in since. The addition of the salt to the water, besides removing to a great extent the air, has the effect of diminishing the correction required for the force of vapour; the last named solution has its boiling-point at 234° F., and, as has been shown by experiments, the tension of vapour from water and watery solutions of salts is the same at an equal number of degrees below their boiling-points, the correction to be applied is lessened to that of pure water 22° lower than the observed temperature. This correction, which is to be added, and that for the expansion of the fluids, which is to be subtracted, thus nearly neutralizing each other at low temperatures, I have applied by means of a moveable scale, in the same way as is used in the sympiesometer. Among the slighter variations shown by this barometer may be mentioned the oscillations during a gale of wind; these are quite as conspicuous in this barometer as they were observed by Professor Daniell in the water barometer, amounting frequently to 0·03, and once to 0·04 of an inch; they vary in duration from 5 to 7 seconds; they begin with a short, quick rise, followed by a slower and much greater descent, and then a return to the point of rest, which is much nearer the top than the bottom of the oscillation. Previously to a gale of wind, the column descends by jerks and with irregular rapidity; but on one occasion, on which no wind followed for two days, the column fell without the slightest jerk more than half an inch; there was, however, a heavy and long-continued fall of rain. During heavy and sudden showers the column rises, and falls again on the cessation of the shower; on one occasion the rise was ·02 of an inch. In a room with a fire, with a door and window shut, the column is lower than when the window is open; the difference is usually ·005, but with a good fire ·01 of an inch. The last two causes are very likely to give rise to error, and the better the barometer the greater will be the error.

[W. R.]

## WEEKLY EVENING MEETING,

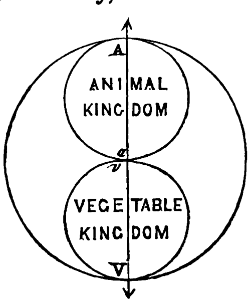
Friday, April 28.

Sir Charles Fellows, Vice-President, in the Chair.

Professor E. Forbes, F.R.S.

*On the manifestation of Polarity in the distribution of Organized beings in Time.*

Of the four relations among organized beings, viz: Affinity (or relation through homology), Analogy, Representation, and Polarity, the three first have been recognized in the distribution of beings in Geological Time; the fourth has neither been observed nor sought for. The term itself is one not familiar in the language of Natural History, although proposed many years ago by the Swedish botanist Fries, and systematically employed by several naturalists for some time past. The word Polarity seems objectionable, since it has been appropriated with a peculiar signification by Physical philosophers. The sense in which it is employed by Naturalists, that of a manifestation of force of development at opposite poles of an ideal sphere, cannot however be indicated by any other word at present invented, implying as it does something very different from *divergence* and from *antagonism*, words which have been suggested as substitutes. The ordinary illustration of the relation of *Polarity*, in a natural history sense, is that representing the relation of opposition or progression in opposite directions of the Animal and Vegetable series; the meeting point of both being at the points of lowest development of each (*a*, *v*, in the accompanying diagram), where the animal and vegetable natures are almost confounded, whilst the strongest manifestations of each are at A and V, the highest animals being farthest removed from the highest vegetables,—in other words, at opposite poles of the sphere of organized beings.




The earnest desire implanted instinctively in every enquiring mind, to discover a law or scheme in arrangements of Nature, has given origin to many speculations concerning the distribution of life in geological time, all of them founded on facts more or less clearly

understood. Hence have arisen the hypothesis of an evolution of all organized types, during the course of time, from one rudimentary prototype; that of the succession of distinctly originating forms of animals and vegetables in order of the progression within their respective series; of the coeval starting of the great groups wholly or mostly at the beginning, but in each instance by the lower forms of the type; of the representation by the faunas and floras of geological epochs, of the successive zones of life belting the geographical regions between the poles and the equator; of an uniformity of life arrangements throughout time and repetition through substitution of equal and similar groups; and of manifestations in the distribution of life in time of analogies that are essentially theological.

For several years I have been persuaded that the simple and unquestionable phenomena of substitution of groups by representative groups, manifested in the arrangements of the faunas and floras of all geological epochs, and comparable with like phenomena exhibited by the geographical distribution of existing organized beings, would prove sufficient for the explanation of all the appearances, that have suggested such speculations, some purely hypothetical, some fairly theoretical, as those I have just indicated. The apparent contradictions and unexplained peculiarities presented by the more ancient epochs as contrasted with the middle and newer ones, seemed to depend on the incomplete state of our knowledge, and to be possibly explainable by supposing, that of some great geological epochs in time we had as yet discovered no traces. Thus the great gap between the Palæozoic and Mesozoic life might depend upon our not yet having discovered traces of the rudimentary formations that had been deposited during the interval between the Permian and Triassic epochs.

But the rapid accumulation of palæontological facts gathered within the last very few years, and the great additions that have been recently made towards our knowledge of the Palæozoic fauna, all mainly in accordance with facts known before, have satisfied me that the explanation offered above does not sufficiently meet the full truth, and that the various theories concerning progression, development, &c. have all originated in the obscure perception and imperfect interpretation of the workings of some great law in the distribution of organic beings in time.

It is no longer possible, in the face of palæontological evidence, to hold any of the notions cited. The scale of the first appearance of groups of beings of any degree is most clearly not one of organic progression. Suitable conditions have been met by the creation of suitable types; no type, whether generic and therefore ideally manifested, or specific and therefore manifested actually and through individuals, visibly, being found to be ever repeated in time, when the full history of either is made out. This is a great law and a grand result of geological research. Nevertheless in the relative arrangements, so to speak, of generic types in time, there is an indi-

cation of the working of a general law of another kind, and one, which seems to me to depend on *the manifestation of the relation of Polarity.*

We are accustomed to group all geological epochs under three great sections, the Palæozoic, or oldest, the Mesozoic or middle, and Cainozoic, more commonly termed Tertiary, or newest. If we consider the faunas (and floras) of these three great sections, we cannot but perceive that there is a far stronger affinity between the Mesozoic and Tertiary epochs than between the Mesozoic and Palæozoic. This is especially manifest when we regard the details of the distribution of those preservable forms of animal life, which being inhabitants of the medium in which sedimentary strata are deposited, are most likely to afford an approach towards complete evidence. On the other hand, the forms of life that characterize the Palæozoic formations, the products of a vast succession of time-periods, have, when regarded in their totality, a wonderful agreement and relationship among themselves.

For this reason I propose to denominate the sum of the epochs after the PALÆOZOIC, by the name of NEOZOIC.

Now if we regard these two great periods separately, we find that the manifestation of generic types during each exhibits striking and contrasting phenomena. *The maximum development of generic types during the Palæozoic period was during its earlier epochs; that during the Neozoic period towards its later epochs.* And thus, during the Palæozoic period, the sum of generic types and concentration of characteristic forms is to be observed in Silurian and Devonian formations; during the Neozoic period it is during the Cretaceous, Tertiary, and present (itself part of the Tertiary) epochs that we find the maximum development of peculiar generic types (or ideas). On the other hand, during the closing epochs of the Palæozoic and the commencing epoch of the Neozoic period there was a poverty in the production of generic ideas, with few exceptions the species of the epochs in question being members of genera that form constituents in the assemblage, accumulated during the epochs of maximum of generic types or ideas.

The following table may render my meaning more evident:

| | | |
|---|---|---|
| Neozoic period | Present and Tertiary epochs | Epoch of maximum development of Neozoic Generic types. |
| | Cretaceous epochs | |
| | Oolitic epochs . . . | . Intermediate. |
| | *Triassic epochs* | *Epochs of poverty of production of Generic types in Time.* |
| Palæozoic period | *Permian epochs* | |
| | Carboniferous epochs . | . Intermediate. |
| | Devonian epochs | Epoch of maximum development of Palæozoic Generic types. |
| | Silurian epochs | |

Before the Silurian and after the *commencement* of the present, no special creations of generic types have as yet been shewn to be manifested. In the system of life of which all known creatures

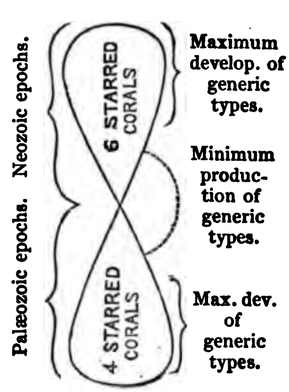
living or extinct as yet described, so far as our knowledge extends — and there is a consistency in its co-ordination that suggests the probability of our being acquainted with its extremes,—the creation of the fauna and flora of the oldest Palæozoic epoch would seem to be the primordial and the appearance of man the closing biological events.

When the assemblage of characteristic Neozoic groups or genera is contrasted with that of the Palæozoic, there we find that the concentration of a maximum development of generic types towards the earlier stages of the one and the later of the other great period, includes something more than a mere numerical profusion of generic ideas. The two great manifestations of creative intensity are in opposition, or contrast, and respectively substitute each other; groups that are parallel within their sub-kingdoms or classes taking the place of each other and playing a corresponding part in the economy of nature. This replacement does not depend on the substitution of a group of higher organization during the latter epoch, for one of lower during the former. Where there is such a substitution it must be regarded as an accident; for the rule is not general nor can it be held good except for a few instances.

A few leading examples of the substitution of group for group during the contrasting epochs are cited in the following table and will illustrate this point better than a mere abstract statement.

| Neozoic. | Palæozoic. |
|---|---|
| Cycloid and Ctenoid Tubes . . | Ganoid and Placoid Tubes. |
| Malacostracous Crustacea . . . | Entomostracous Crustacea. |
| Dibranchiate Cephalopoda . . . | Tetrabranchiate Cephalopoda. |
| Lamellibranchiate Acephala . . | Palliobranchiate Acephala. |
| Echinoidea . . . . . . . . | Crinoidea. |
| 6-starred Corals . . . . . . . | 4-starred Corals. |

If we were to shew by means of a detailed diagram the relations in each of these groups of the development of generic types to time, we should symbolise it by a cone or a pyramid, the base or fullest portion of which should be turned respectively towards the commencement of the Palæozoic, or termination of the Neozoic epoch. The last example given will shew this strikingly, though in most instances the groups interlace.

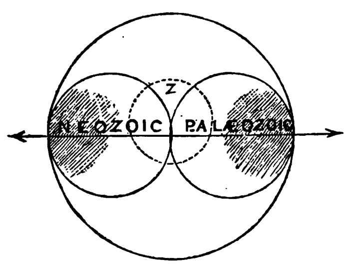



Relations of this kind may be manifested in a low degree, even within the range of a single group.

From all these considerations, the numbers of species in a group or genus at any given epoch is to be excluded, not being an element in the discussion of the question, though apt to be introduced through mistake of the nature of the generalization attempted to be attained.

There may appear to be a contradiction involved in the expression *manifestation of polarity in time*, for since time implies sequence or progression in one direction only, how can we connect with time an arrangement that involves the notion of progression in opposite directions, proceeding from a median zero?

But time is an attribute with which man's mind invests creation; a mode of regarding Divine ideas, necessary for the conception of time by our limited faculties and forming in itself no part or essence of the Divine scheme of organized nature. We speak of Polarity in Time, for want of a better phrase: but this polarity, or arrangement in opposite directions with a development of intensity towards the extremes of each, is itself, if I am right in my speculations, an attribute or regulating law of the divinely originating scheme of creation, therefore strictly speaking independent of the notion of time, though perceptible by our minds only in connection with it.




By a diagram such as the above we may fairly express this view, the shaded portions of the circles included within the great circle of the system of nature representing the maxima of development of generic ideas, and the dotted area, *z*, the region of their minimum productions.

In venturing on a speculation of this kind I am aware that it is subject to much misrepresentation and liable to be misunderstood; the more so since the suggestion must precede the demonstration. At present it can scarcely be received as more than a suggestion; one put forth as worthy of consideration. But in issuing it I do so keeping in view a vast number of individual facts and base it upon the results of investigations of no small extent. To lay these before the scientific world in detailed and tabulated shape will be the work of more leisure than can at present be given to the task. In the hope of acquiring fresh data for this investigation I, rashly as some may think, make public this hypothesis. That it is the only

one of its class which holds out a prospect of eliminating the germs of truth contained in the conflicting theories at present more or less in vogue, and the only one with which the presence of species of any group of organized beings at any geological epoch will not disagree, are surely considerations that should secure for it a friendly reception. If it be as true, as I believe it to be, then the truth that it contains is most important; if it prove in the end to be a misinterpretation, it will at least have served the good purpose of stimulating inquiry in a fresh direction.

[E. F.]

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## ANNUAL MEETING,

Monday, May 1.

William Pole, Esq., M.A., F.R.S., Treasurer and Vice-President, in the Chair.

The Annual Report of the Committee of Visitors was read, and adopted.—It states that the Contributions from Members and Annual Subscribers in 1853 have been very satisfactory, as well as the Receipts for attendance at the courses of Lectures. The total Receipts amounted to £4428, being an increase of Income beyond that of any preceding year; in consequence of which the Managers have been enabled to make investments to the extent of £600.

The appointment of Dr. Tyndall on the 4th of July, 1853, as Professor of Natural Philosophy in the Royal Institution, the Visitors consider will tend to elevate the character of the Institution.

A List of Books Presented accompanies the Report, amounting in number to about 290 volumes, and making a total, with those purchased by the Managers and Patrons, of more than 1100 volumes (including Periodicals) added to the Library in the year.

Thanks were voted to the President, Treasurer, and Secretary, to the Committees of Managers and Visitors, and to Professor Faraday, for their services to the Institution during the past year.

The following Gentlemen were unanimously elected as Officers for the ensuing year: —

President — The Duke of Northumberland, K.G. F.R.S.

Treasurer — William Pole, Esq. M.A. F.R.S.

Secretary — Rev. John Barlow, M.A. F.R.S.

MANAGERS.

Lord Ashburton, F.R.S.
William Wilberforce Bird, Esq.
John Bate Cardale, Esq.
J. Griffith Cole, Esq., M.A.
James William Farrer, Esq.
Aaron Asher Goldsmid, Esq.
William R. Grove, Esq., Q.C. F.R.S.
Sir Henry Holland, Bart., M.D., F.R.S.
Henry Bence Jones, M.D., F.R.S.
Edward Kater, Esq., F.R.S.
George Macilwain, Esq.
Frederick Pollock, Esq., M.A.
Alfred S. Taylor, M.D. F.R.S.
Charles Wheatstone, Esq., F.R.S.
Colonel Philip J. Yorke, F.R.S., Pres. Chem. Soc.

VISITORS.

J. G. Appold, Esq., F.R S.
John Charles Burgoyne, Esq.
William Carpmael, Esq.
Alexander Crichton, Esq.
The Earl of Ducie.
Edward M. Foxhall, Esq.
Frederick Gaussen, Esq.
Colonel Francis Vernon Harcourt, M.P.
John Holdship, Esq.
John Kirkpatrick, Esq.
John Gorham Maitland, Esq.
Robert R. I. Morley, Esq.
John North, Esq.
Rev. William Taylor, F.R.S.
Henry Twining, Esq.

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## WEEKLY EVENING MEETING,

Friday, May 5.

The Rev. JOHN BARLOW, M.A., F.R.S., Secretary, R.I., in the Chair.

HENRY M. NOAD, PH. D.

LECTURER ON CHEMISTRY AT ST. GEORGE'S HOSPITAL.

### *On the Manufacture of Iron.*

THE history of this important metal was first briefly sketched; it was shown by reference to the four books of the Mosaic law, that it was known and used in the earliest ages of the world: from various passages in Hesiod, Homer, and Æschylus it was rendered probable that the ancient Greeks, though acquainted with both iron and bronze, used the latter in the construction of their warlike weapons till the period of the Heroic ages; but that after that time bronze was superseded by iron obtained from the Chalybes: and from passages from the writings of Polybius, Pliny, and Diodorus, the conclusion was drawn that even in the earliest times the Romans used weapons of iron which they obtained principally from Spain. It was mentioned, on the authority of Mr. Arthur Aikin, as a curious fact, that cutting and even surgeons' instruments were found in the excavations at Herculaneum and Pompeii made of *bronze*, though some were also found of iron; from which it was to be concluded

that at this period (about the year 59) the great superiority of iron over every other kind of metal in the manufacture of cutlery was only partially acknowledged.

A glance was next taken at the different ores of iron. Upwards of forty species have been described, the metal occurring in all rocks, into the composition of the greater number of which it enters as a base to silicic acid.

The following ores (as the most important) were exhibited and described:—

1°. *Specular, oligistic, and micaceous iron*, of which there are several varieties differing greatly in appearance, but all when pure represented by the formula $Fe_2\ O_3$. The principal localities in this country are Ulverstone in Lancashire, where it often occurs in large botryoidal masses, and is hence called kidney ore; and the Forest of Dean, where it is much mixed with carbonate of lime; the specular variety is found in Cornwall. This variety of ore always yields good and strong iron; it greatly improves all inferior ores, and forms an excellent flux in the blast furnace. It is from the specular ore that the celebrated "damask iron" of Persia, and the "wootz" of India are manufactured.

2°. *Hydrated oxide or brown Hæmatite.*—This ore, which usually contains about 14 per cent. of water, and is represented by the formula $2\ Fe_2\ O_3 + 3\ HO$, is not found in any quantity in this country, though it occurs at Alston Moor and in Durham; it abounds however in Normandy, Berry, Burgundy, and Lorraine, and supplies the greater number of the French iron-works.

3°. *Aimantine or magnetic Iron ore.*—This ore, the richest of all in metal, and composed of $Fe\ O + Fe_2\ O_3$, is not found in any abundance in this country. It exists plentifully in Norway and Sweden, in Germany, in India, and in the states of New York and New Jersey in America. The iron furnished by it is of the finest description.

4°. *Carbonates.*—Of the pure white carbonate, *Spathoze iron, siderose* or *iron spar*, we do not possess any large quantities in this country. It has lately however been found in Somersetshire, and is remarkable for containing a large per centage of manganese.

*The Ironstone of the Coal formations.*—It is to the richness of our coal fields in the argillaceous and blackband ironstone, that the surprising increase in the production of iron during the last hundred years is to be attributed. It is calculated that this ore supplies $\frac{8}{10}$ths of the entire iron produced. It is not found in all coal fields; those of Northumberland, Durham, Lancashire, Leicestershire, and Somersetshire do not furnish any important supplies. The coal basin of South Wales, comprising an area of 1045 square miles, yields the largest quantity of iron; then follow Staffordshire, Shropshire, Yorkshire, Derbyshire, and North Wales. This ore is especially valuable, from its occurring in close proximity to the very materials required for its smelting, viz. to coal and limestone. It is frequently

found in egg-shaped masses of various sizes; and on carefully splitting these in a longitudinal direction, it is not unusual to find in the centre, as a sort of nucleus round which the carbonates of iron and lime and of clay have arranged themselves, a shell or a vegetable remain. [One of these in a great state of perfection, from the Cwm Celyn Iron-works in South Wales, was on the table.]

The *Oolitic Ironstones* of Northamptonshire are also beginning to excite considerable attention. They are found, in largest quantity and best quality, along the Northampton and Peterborough line from Higham Ferrers to Hardingstone near Northampton; and from Gayton near Blisworth to Towcester. They are of very varied character, and the per centage of iron which they contain ranges from 20 to 55 per cent.

*Treatment of the Coal measure Ironstone.*—The ore occurs in beds of varying thickness and generally inclined to the horizon. There are usually several beds or seams one beneath another, separated by beds of other minerals, and in all such cases every bed has a local name, frequently of a very fanciful nature, applied to it. The ore is stacked and exposed for some months to the weather, during which time the outer coating, containing but a small quantity of iron, cracks and falls off. The first process that it undergoes is that of roasting, which is performed either in the open air or in kilns, the latter being most effectual; by this process it loses *water and carbonic* acid, the loss of weight being about 25 per cent.; and the iron from being in the state of carbonate, is brought into the state of peroxide, and is now in the form of a red, more or less porous mass, a state in which it can be acted upon more readily in the furnace. By roasting, the ore also loses the sulphur, though the ironstones of Cwm Celyn, to which the Lecturer's attention has been more particularly directed, contain very small quantities of that pernicious element.

The amount of carbonate of iron in the coal measure ironstones, varies from 50 to 80 per cent.—the other constituents being silica, alumina, lime, and magnesia, with minute quantities of sulphur, phosphorus, and potash.

The Blast-furnace was next described. The outer stack is composed of stone or brick, within which is a casing of masonry about fourteen inches thick, which when the furnace requires to be renewed inside, admits of being taken down and rebuilt without injury to the outer fabric; next comes a space of about six inches filled with river sand compactly rammed in,—which being a bad conductor of heat tends to preserve the casing of masonry; lastly, a coating of best fire brick about fourteen inches in thickness.

The following are the names and dimensions of the internal parts of the furnace. 1st, The *hearth*, which may be from three to six feet in width. 2nd, The *boshes*,—height from twelve to sixteen feet; width from twelve to fifteen feet. 3rd, The *cone* or *cavity*, height from thirty to thirty-six feet;—total height of the furnace from forty-five to fifty feet. The furnace when in full work contains upwards of one

hundred tons of materials, to supply the requisite heat for which, a powerful and constant blast of air is sent in at three or four different sides through tubes surrounded with a stream of cold water, and which are called "Tuyeres." Some of the large Welsh furnaces consume upwards of 20,000 gallons of air per minute, a quantity exceeding in weight the totals of all the solid materials used in smelting. The blast enters the furnace under a pressure of from two to three pounds and a half to the square inch, and (unless previously heated) at a lower temperature than the external air, in consequence of its compression in the blowing machine, by which latent heat is separated and lost, which heat it again obtains at the expense of surrounding objects as it escapes in its recovered state of expansion from the Tuyere. It is almost the universal rule, however, at the present time to heat the air to about 600° before it enters the furnace, by which an effective increase of about $\frac{1}{8}$th or of 360° F is obtained. The influence which this capital improvement (first introduced about twenty-five years ago by Mr. Neilson at the Clyde Iron-works) has had on the iron manufacture has been immense. It has in many cases enabled manufacturers to increase their weekly production of iron 50 per cent., and to produce a better sort of cast-iron from inferior materials. It has effected a great saving of fuel; and it has enabled the Scotch Iron-masters to smelt alone and with coal the *black band* ironstone discovered by Mr. Mushet in 1801.

The great importance of the hot blast, and the influence of an uniform temperature on the working of the furnace, is well shown by the following statement furnished by F. Levick, Esq. the intelligent Manager of the Cwm Celyn and Blaina Works. (The Lecturer took the occasion of mentioning this gentleman's name, to express the obligations he was under to him for the facilities he had repeatedly offered him for studying the details of the iron manufacture at the above admirably conducted works, and for the specimens of the various interesting products which were on the table.)

It is to be understood that both furnaces were making *White* or Forge Iron to be afterwards manufactured into Railway bars.

No. 1. *Furnace at Cwm Celyn;—one week's work, ending 7th April,* 1854.

The blast was not sufficiently heated, the blast stoves being out of repair, and the furnace was "scouring."

*Charges driven,* 652; *Iron made,* 181 tons 9 cwt.

Consumption of fuel on the ton of Iron made.

| | Cwt. | | | Tons. Cwt. | | Cwt. |
|---|---|---|---|---|---|---|
| Coal burthen | 10 | 378 Charges | = | 189 .. 0 | = | 20·88 |
| Coke ,, | $6\frac{1}{2}$ | 274 . . | = | 88 .. 11 | = | 9·78 |
| | $16\frac{1}{2}$ | 652 | | | | 30·66 |

*Mineral burthen.*

| | | | Tons Cwt. | | Cwt. |
|---|---|---|---|---|---|
| Limestone | 1 cwt. | . . . | 32 .. 12 | = | 3·60 |
| Welsh Mine | 10 cwt. | . . . | 326 .. 0 | = | 36·02 |
| Red ore | 1 „ | . . . | 32 .. 12 | = | 3·60 |
| Cinder | 4 „ | . . . | 130 .. 8 | = | 14·40 |
| | 15 cwt. | | 489 .. 0 | | 54·02 = |

= Consumption of Iron minerals per ton of Iron made.

No. 2. *Furnace at Cwm Celyn;—one week's work, ending 7th April,* 1854; *working well.*

*Charges driven,* 652; *Iron made,* 236 tons 16 cwt.

| | Cwt. | | | Tons Cwt. | | Cwt. |
|---|---|---|---|---|---|---|
| Coal burthen | 10 | 380 Charges | = | 190 .. 0 | = | 16·03 |
| Coke . . | $6\frac{1}{2}$ | 272 „ | = | 81 .. 12 | = | 6·88 |
| | | 652 | | | | 22·91 = |

= Consumption of fuel per ton of Iron made.

*Mineral burthen.*

| | | | Tons Cwt. | | Cwt. |
|---|---|---|---|---|---|
| Limestone & | $\frac{1}{2}$ cwt. } | . . . | 46 .. 4 | = | 3·89 |
| Welsh mine | 11 cwt. | . . . | 358 .. 12 | = | 30·26 |
| Red ore | 2 „ | . . . | 65 .. 4 | = | 5·50 |
| Cinders | 6 „ | . . . | 195 .. 12 | = | 16·50 |
| | 19 cwt. | | 619 .. 8 | | 52·26 = |

= Consumption of minerals per ton of Iron made.

From this statement it appears that with the same number of charges, No. 2 made during the week 55 tons 7 cwt. more iron than No. 1; that while No. 1 took nearly 31 cwt. of fuel to make a ton of iron, No. 2 took only 23 cwt.; that No. 1 carried a "burthen" of 15 cwt. of iron minerals on each charge of fuel, and No, 2, 19 cwt.; and that while No. 1 required 54 cwt. of iron minerals to make one ton of iron, No. 2 required 52 cwt. 26 lbs. only.

The colour, consistence, and general appearance of the *scoriæ, cinders,* or *slag,* are to the furnace manager good general indications of the manner in which his furnace is working. When *white* iron is being made, a good cinder will have a clear olive green colour, and will flow regularly and smoothly from the tap-hole; a "scouring"

cinder on the other hand, such as was flowing from No. 1, is thick, runs from the tap-hole with difficulty, has a dull, nearly black colour, and is very heavy; in fact analysis shows that it contains 20 per cent. of oxide of iron. The cinder from the *gray* or foundry iron furnace has altogether a different appearance, but both *white* and *gray* cinders are nearly as interesting to the chemist and mineralogist, as they are to the iron manufacturer. They are received from the furnace in large iron boxes, whence, as soon as they have solidified, they are removed on railroads to be used for the construction of roads, rough walls, &c. The outside of the cinder lumps, "donkeys" as they are called by the workmen, have a vitreous fracture; but the interior, where the cooling process has taken place very slowly, is stony, and usually contains cavities which are lined with crystals; those from white iron have a composition which places them among the *pyroxene* or *augite* class of minerals; those from grey iron are more nearly allied to *idocrase*. [Reference was here made to a Table giving the per centage composition of three varieties of crystalline slags obtained from the *Cwm Celyn* works.]

The iron from the blast furnace is usually "tapped" twice in twenty-four hours; the liquid metal is either received into moulds where it assumes the form of semi-cylindrical bars, technically called "pigs," or it is run into wider channels from which, after being broken up, it is removed directly to the "refinery."

The "cinders" alluded to in the above statement of the mineral burthens of the two Cwm Celyn furnaces, are not the cinders of the blast furnace, but "forge cinders;" that is, the cinders that separate from the cast iron during the processes of "refining," "puddling," and "balling," by which the cast iron is converted into wrought iron. These cinders are very rich in iron, which exists principally in the form of silicate of the protoxide; they often occur beautifully crystallized, particularly after they have been "calcined," an operation which is now always performed on them in well conducted works, and which has for its object the removal of the sulphur and the peroxidation of a portion of the iron: the tendency of sulphur even when it exists in iron in very small quantity, is to make the metal what is called "hot short," so that it cannot be worked under the hammer; the tendency of phosphorus, another element always found in "forge cinders" is to make the iron "cold short," so that it breaks on attempting to bend it. The separation of sulphur, by calcining, is very perfectly effected, and it is interesting to trace the process of its gradual elimination; in some places large masses of prismatic crystals of pure sulphur are seen, but usually nearly the entire surface of the heap is covered with a thin layer of sulphate of iron, sometimes crystallized, but generally in various stages of decomposition; lower down in the heap, where the heat is greater, the sulphate of iron disappears, and in its place "colcothar" is found. The separation of phosphorus from the forge cinders is still a desideratum. [Specimens of forge cinders, raw and calcined, crystal-

lized and amorphous, were here exhibited, and Tables exhibiting numerous analyses of them were referred to.]

*Theory of the Blast-Furnace.*—Though much has been written on this subject, it can scarcely be said that any very sound scientific views were entertained respecting the theory of the Blast-Furnace previous to the beautiful researches of Professors Bunsen and Playfair, and more recently those of the late lamented Professor Ebelmen, on the gases evolved from the furnace at different depths.

Tables in which these experiments were compared were referred to; the difference in the results may in a great measure be explained by the circumstance that the English furnace (Alfreton, in Derbyshire) was working entirely with coal, whereas the Seraing furnace, on which M. Ebelmen's experiments were made, was working with *coke* alone; this would at any rate explain the difference as relates to the carburetted hydrogen, and hydrogen gases; mere traces of the former were found by Ebelmen, while Bunsen and Playfair found as a maximum 8·23 per cent. of the former, and 12·42 per cent of the latter. As it is probable, however, that neither of these gases takes any share in the reduction of the ore, their presence or absence will not materially interfere with the discussion of the theory of the blast-furnace.

Both series of analyses shew, what at first sight appears most remarkable, viz.: that the gases in the immediate neighbourhood of the blast do not contain a *trace* of carbonic acid; shewing that powerful oxidizing and de-oxidizing actions must take place at that point. Here also in the English furnace were found *Cyanogen* and vapours of *Cyanide of potassium;* in the *Seraing* furnace no *Cyanogen* was detected, but abundance of *Cyanide of potassium* and vapours of *oxide of zinc*. The Cyanide of potassium, which, doubtless from its powerful reducing action exercises an important influence on the reduction of the stubborn forge cinder, is formed by the action of the nitrogen of the blast, on the red hot carbon of the fuel in the presence of potash derived from the ore. Bunsen and Playfair calculated that in the Alfreton furnace 224·7 lbs. of this salt were produced daily.

The conclusions deduced by Bunsen and Playfair from their gas analyses are, that the reduction of the iron minerals, and the disengagement of carbonic acid from the limestone, takes place at a depth of between 24 and 25 feet, that is in the *boshes* of the furnace, the cone or body of the furnace being entirely taken up in the process of *coking* the coal. Ebelmen thinks, on the other hand, that the rapid diminution of carbonic acid and corresponding increase of carbonic oxide in descending the furnace, which are shewn by his analyses, indicate conclusively that an energetic reduction of ore takes place in the vicinity of the mouth of the furnace, that reduction being effected by carbonic oxide under the influence of the high temperature of the ascending gases without any change in the volume of the gas, and without any consumption of fuel. This mutual relation of the car-

bonic acid and carbonic oxide gases is not observable in the analyses of Bunsen and Playfair, which Ebelmen attributes to the circumstance that those chemists collected their gases through narrow iron tubes, which, becoming intensely heated and partially choked by the fragments of ore and fuel introduced by the rapid stream of gas, so modified the composition of the gases that the analyses, however carefully conducted, could not represent accurately the actual composition of the furnace gases. Ebelmen collected his gases through wide tubes, and from the lower part of the furnace, by piercing the solid masonry. According to Ebelmen's analyses, the gases between the depths of 12 and 45 feet are composed almost entirely of carbonic oxide and nitrogen. The proportion of oxygen to nitrogen at 12 feet is as 29·9 to 100; in atmospheric air it is as 26·3 to 100; the difference amounting to 3·6 represents the oxygen arising from the bed of fusion from the Tuyeres to this height. It arises from the reduction of the silicates of iron constituting the forge cinders, which takes place between the Tuyeres and the depth of 12 feet. Without wishing in the slightest degree to impugn the accuracy of Bunsen and Playfair's analyses, it was considered that the conclusions of Ebelmen accord best with the general phenomena of the Blast-furnace, inasmuch as if the reduction of the ore only takes place in the *boshes* as the former chemists suppose, there seems no reason why furnaces should not be built one half their present height, and the fuel consist entirely of coke. It is found, however, practically impossible to reduce materially the height of the furnace; but this is at once intelligible, if we suppose that the oxide of iron is reduced principally in the cone, and that in its descent through the boshes to the crucible *it acquires from the fuel* that proportion of carbon which it requires to bring it to the state of fusible cast iron. It is very desirable, however, that this interesting chemical question should undergo further elucidation at the hands of some chemist properly skilled in the difficult subject of gaseous analyses.

The practical application of the furnace gases was lastly briefly alluded to. It was shown on the authority of Bunsen and Playfair, and from calculations deduced from data furnished by the posthumous papers of Dulong, that of the heat produced by the combustion of the fuel in a coal-fed blast furnace, only 18·5 per cent. is realized in carrying out the processes of the furnace, the remainder 81·5 per cent. being lost. This loss in well conducted establishments is no longer permitted. The gases are now collected at the mouth of the furnaces and conveyed by large pipes underneath the boilers of the engines and round the hot air stoves. The principle has been carried out in great perfection at Cwm Celyn: the pipes are six feet in diameter, and are lined with fire-brick; and the gases from *two* furnaces only more than suffice for the supply of seven boilers, and for the hot blast for both furnaces, at a saving of full 10,000 tons of coal a year. [Drawings on a scale of one inch to the foot showing the entire arrangement were exhibited and referred to.]

[H. M. N.]

Mr. FARADAY exhibited a piece of the Submarine Electro-telegraph cable (from Mr. Crampton), consisting of four insulated copper wires surrounded by packing, and then by ten external iron wires or rods to give protection, weight, and strength. A kink or sharp short twist which occurred in the laying it down under the full force of the steam-tug had somewhat deranged the wires, but had broken nothing nor caused any interference with the insulation, and for two full years that part acted telegraphically in the sea as well as any other part of the cable.

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## GENERAL MONTHLY MEETING,

Monday, May 8.

WILLIAM WILBERFORCE BIRD, ESQ., Vice-President, in the Chair.

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| John Laing, Esq. | Joseph Skey, M.D. |
| William Nicol, Esq. | Matthew William Thompson, Esq., M.A. |

were duly *elected* Members of the Royal Institution.

Matthew Noble, Esq.

was *admitted* a Member of the Royal Institution.

The following Professors were unanimously re-elected: —

WILLIAM THOMAS BRANDE, Esq.. D.C.L., F.R.S. L. & E., as Honorary Professor of Chemistry in the Royal Institution.

JOHN TYNDALL, Esq., Ph.D., F.R.S., as Professor of Natural Philosophy in the Royal Institution.

The following PRESENTS were announced, and the thanks of the Members returned for the same; —

FROM

*Actuaries, Institute of* — The Assurance Magazine, No. 15. 8vo. 1854.
*Asiatic Society of Bengal* — Journal, No. 238. 8vo. 1853.
*Astronomical Society, Royal* — Monthly Notices, Vol. XIV. No. 5. 8vo. 1854.
*Bell, Jacob, Esq.* — Pharmaceutical Journal, May, 1854. 8vo.
*Best, Hon. and Rev. Samuel, M.R.I. (the Author)* — Thoughts for the Improvement of the Civil Service. 8vo. 1854.
*Boosey, Messrs. (the Publishers)* — The Musical World for April, 1854. 4to.
*British Architects, Royal Institute of* — Proceedings in April, 1854. 4to.
*Cambridge Philosophical Society* — Transactions, Vol. IX. Part 3. 4to. 1853.
*Civil Engineers, Institution of* — Proceedings in April, 1854. 8vo.
*East India Company, the Hon.* — Rig-Veda-Sanhita, the Sacred Hymns of the Brahmans. Edited by Max Müller, M.A. Vol. II. 4to. 1854.

*Editors* — The Medical Circular for April, 1854. 8vo.
The Athenæum for April, 1854. 4to.
The Practical Mechanic's Journal for May, 1854. 4to.
The Mechanics' Magazine, for April, 1854. 8vo.
The Journal of Gas-Lighting, April, 1854. 4to.
Deutsches Athenäum, May, 1854.
Our Friend, Nos. 1—5. 8vo. 1854.
*Faraday, Professor, D.C.L., F.R.S. &c.*—Recherches Expérimentales sur la Végétation. Par M. Georges Ville. 4to. Paris, 1853.
Monachtsbericht der Konigl. Preuss. Akademie, Feb. 1854. 8vo. Berlin.
*Franklin Institute of Pennsylvania* — Journal, Vol. XXV. No. 5. 8vo. 1853. Vol. XXVII. No. 4. 8vo. 1854.
*Gerling, Dr.* — Graphische Darstellung der Magnetischen Deklination zu Marburg. 1848—1852. fol.
*Graham, George, Esq. Registrar-General* — Weekly Reports of the Registrar-General for April, 1854. 8vo.
*Hawes, William, Esq. (the Author)* — Observations on Limited and Unlimited Liability. 8vo. 1854.
*Horticultural Society of London* — Journal, Vol. IX. No. 2. 8vo. 1854.
*Kay, John William, Esq. (the Editor)* — Memorials of Indian Government; being a Selection from the Papers of H. St. George Tucker, late Director of the East India Company. 8vo. 1853.
*Liverpool Literary and Philosophical Society* — Proceedings for 1851—1853. 8vo. 1854.
*Lovell, E. B. Esq. (the Editor)* —The Monthly Digest, April, 1854. 8vo.
The Common Law and Equity Reports, Parts 10, 11, & 12. 8vo. 1854.
*Madras Literary Society* — Madras Journal of Literature and Science. Vols. I. II. & XIII.—XVI. & Vol. XVII. Part 1. 8vo. Madras, 1833—53.
*Novello, Messrs. (the Publishers)* —The Musical Times, May, 1854. 4to.
*Phillipps, Sir Thomas, Bart., F.R.S. F.S.A. M.R.I. (the Author)* — Catalogue of Knights made by Charles I. 1624—46.
*Photographic Society* — Journal, No. 16. 8vo. 1854.
*Royal Society of London* — Proceedings, Vol. VII. Nos. 1, 2. 8vo. 1854.
*Sharpe, Hercules, Esq., M.R.I.* — Certain Sermons or Homilies, appointed to be read in Churches. 12mo. 1687.
*Society of Arts* — Journal for April, 1854. 8vo.
*Stodart, George, Esq., M.R.I.* — The Poetical Works of the late Catherine Grace Godwin. Edited, with a sketch of her Life, by A. Cleveland Wigan. 4to. 1854.
*Taylor, Rev. W., F.R.S., M.R.I.* — Grosse und gute Handlungen Russischer Regenten, Feldherrn, Staatsbeamten, und Anderer. 8vo. Berlin, 1804.
*Taylor, James, Esq. (the Author)* — An Examination of Galena in the various processes of the Manufacture of Lead. 8vo. 1854.
*Twining, Thomas, jun. Esq., M.R.I.* — Amtlicher Bericht über die 29te Versammlung der Gesellschaft deutscher Naturforscher und Aerzte zu Wiesbaden im September, 1852. Herausgegeben von Professor Fresenius und Dr. Braun. 4to. Weisbaden, 1853.
*Vereins zur Beförderung des Gewerbfleises in Preussen* — Verhandlungen, Jan. und Feb. 1854. 4to. Berlin.
*Ward, F. O. Esq., (the Author)* — Moyen de créer des Sources Artificielles d'Eau pure pour Bruxelles, &c. 8vo. Bruxelles. 1853.

## WEEKLY EVENING MEETING,

Friday, May 12.

SIR HENRY HOLLAND, Bart., M.D., F.R.S., Vice-President, in the Chair.

THOMAS HUXLEY, ESQ. F.R.S.

*On the common Plan of Animal Forms.*

THE Lecturer commenced by referring to a short essay by Göthe — the last which proceeded from his pen — containing a critical account of a discussion bearing upon the doctrine of the Unity of Organization of Animals, which had then (1830) just taken place in the French Academy. Göthe said that, for him, this controversy was of more importance than the Revolution of July which immediately followed it — a declaration which might almost be regarded as a prophecy; for while the *Charte* and those who established it have vanished as though they had never been, the Doctrine of Unity of Organization retains a profound interest and importance for those who study the science of life.

It would be the object of the Lecturer to explain, how the controversy, in question arose, and to shew what ground of truth was common to the combatants.

The variety of Forms of Animals is best realized, perhaps, by reflecting, that there are certainly 200,000 species, and that each species is, in its zoological dignity, not the equivalent of a family or a nation of men, merely, but of the whole Human Race. It would be hopeless to attempt to gain a knowledge of these forms, therefore, if it were not possible to discover points of similarity among large numbers of them, and to classify them into groups,— one member of which might be taken to represent the whole. A rough practical classification, based on obvious resemblances, is as old as language itself; and the whole purpose of Zoology and Comparative Anatomy has consisted chiefly in giving greater exactness to the definition and expression of these intuitive perceptions of resemblance.

The Lecturer proceeded to shew how the celebrated Camper illustrated these resemblances of the organs of animals, by drawing the arm of a man, and then by merely altering the proportions of its constituent parts, converting it into a bird's wing, a horse's foreleg, &c. &c. Organs which can in this way be shewn to grade into one another, are said to be the same organs, or in anatomical phraseology are *Homologous* :— and by thus working out the homologies of all the organs of the Vertebrate class, Geoffroy, Oken, and Owen,— to the last of whom, we are indebted for, by far, the most elaborate

and logical development of the doctrine,— have demonstrated the homology of all the parts of the Vertebrata, or in other words, that there is a common plan on which all those animals which possess back-bones are constructed,

Precisely the same result has been arrived at, by the same methods, in another great division of the Animal Kingdom — the *Annulosa*. As an illustration, the Lecturer shewed how the parts of the mouth of all insects were modifications of the same elements, and briefly sketched the common plan of the Annulosa, as it may be deduced from the investigations of Savigny, Audouin, Milne-Edwards, and Newport.

Leaving out of consideration (for want of time merely,) the *Radiate* animals, and passing to the remaining great division, the *Mollusca*,— it appears that the same great principle holds good even for these apparently unsymmetrical and irregular creatures: and the Lecturer, after referring to the demonstration of the common plan upon which those Mollusks possessing heads are constructed,— which he had already given in the Philosophical Transactions, — stated that he was now able to extend that plan to the remaining orders, and briefly explained in what way the 'Archetypal Mollusk' is modified in the *Lamellibranchs, Brachiopoda, Tunicata*, and *Polyzoa*.

We have then a common plan of the *Vertebrata*, of the *Articulata*, of the *Mollusca*, and of the *Radiata*,— and to come to the essence of the controversy in the Académie des Sciences — are all these common plans identical or are they not?

Now if we confine ourselves to the sole method which Cuvier admitted — the method of the insensible gradation of forms — there can be doubt that the Vertebrate, Annulose, and Molluscan plans are sharply and distinctly marked off from one another, by very definite characters; and the existence of any common plan, of which they are modifications, is a purely hypothetical assumption, and may or may not be true. But is there any other method of ascertaining a community of plan beside the method of Gradation?

The Lecturer here drew an illustration from Philology— a science which in determining the affinities of words also employs the method of gradation. Thus *unus, uno, un, one, ein*, are said to be modifications of the same word, because they pass gradually into one another. So *Hemp, Hennep, Hanf*, and *Cannabis, Canapa, Chanvre*— are respectively modifications of the same word: but suppose we wish to make out what, if any, affinity exists between *Hemp* and *Cannabis* — the method of gradations fails us. It is only by all sorts of arbitrary suppositions that one can be made to pass into the other.

Nevertheless modern Philology demonstrates that the words are the same, by a reference to the independently ascertained laws of change and substitution for the letters of corresponding words, in the Indo-Germanic tongues: by shewing in fact, that though these

words are not the same, yet they are modifications by known developmental laws of the same root.

Now Von Bär has shewn that the study of development has a precisely similar bearing upon the question of the unity of organization of animals. He indicated, in his masterly essays published five and twenty years ago, that though the common plans of the adult forms of the great classes are not identical, yet they start in the course of their development from the same point. And the whole tendency of modern research is to confirm his conclusion.

If then with the advantage of the great lapse of time and progress of knowledge, we may presume to pronounce judgment where Cuvier and Geoffroy St. Hilaire were the litigants—it may be said that Geoffroy's inspiration was true, but his mode of working it out false. An insect is not a vertebrate animal, nor are its legs free ribs. A cuttlefish is not a vertebrate animal doubled up. But there was a period in the development of each, when insect, cuttlefish, and vertebrate were undistinguishable and had a *Common Plan*.

The Lecturer concluded by remarking, that the existence of hotly controverted questions between men of knowledge, ability, and especially of honesty and earnestness of purpose, such as Cuvier and his rival were, is an opprobium to the science which they profess. He would feel deeply rewarded if he had produced in the minds of his hearers, the conviction that these two great men—friends as they were to one another—need not be set in scientific opposition; that they were both true knights doing battle for science; but that as the old story runs, each came by his own road to a different side of the shield. [T. H.]

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## WEEKLY EVENING MEETING,

Friday, May 19.

W. R. Grove, Esq., Q.C., F.R.S., Vice-President, in the Chair.

John Tyndall, Esq., Ph.D., F.R.S.

PROFESSOR OF NATURAL PHILOSOPHY IN THE ROYAL INSTITUTION.

### *On some Phenomena connected with the Motion of Liquids.*

The Lecturer commenced by referring to certain phenomena exhibited by liquids, and at variance with our commonly received notions as to their non-cohesive character. According to Donny, when the air has been as far as possible expelled

from water by persistent boiling, such water possessess an extraordinary cohesive power, sufficient indeed to permit of its being heated to a temperature of 275° Fah. without boiling. The adhesion of water thus prepared to the surface of a glass tube was shewn experimentally; the force being sufficient to sustain a column of water of considerable height. The contractile force of a soap-bubble was referred to; and the Lecturer passed on to the exhibition of the phenomena resulting from the shock of two opposing liquid veins. In this case, though the forces are in opposite directions, motion is not annihilated; but the liquid, as first shewn by Savart, spreads out so as to form a thin transparent film, the plane of which is at right angles to the direction of the jets. By varying the pressure on one side or the other, or by making the jets of different diameters, the plane film could be converted into a curved one, and sometimes actually caused to close, so as to form a pellucid sack. A cistern, situated at the top of the house and communicating by pipes with the lecture table, placed a considerable pressure at the disposal of the Lecturer, and enabled him to exhibit in a striking manner the various phenomena described by Savart in his researches on the motion of liquids. A vein was caused to fall vertically upon a brass disk upwards of three inches in diameter: the liquid spread laterally on all sides and formed an umbrella-shaped pellicle of great size and beauty. With a disk of an inch in diameter, a pellicle of at least equal magnitude was formed. When a candle was placed underneath the curved sheet of water a singular effect was produced. The film above the candle was instantly dissipated; and on moving the candle, its motion was followed by a corresponding change of the aqueous surface. On turning a suitable cock so as to lessen the pressure, the curvature of the film became increased, until finally the molecular action of the water caused it to form a curve returning upon itself, and exhibiting the appearance of a large flask. When the film completely embraced the vertical stem which supported the brass disk, a change in the form of the liquid flask was observed, the latter became elongated, and was sometimes divided into two portions, one of which glided down the vertical stem and was broken at its base. When the jet was projected vertically upwards, large sheets were also obtained. The jet was also suffered to fall into small hollow cones of various apertures, and the shape of the liquid sheet received thereby some beautiful modifications. The inclosed sides of the hollow cone gave the liquid an ascending motion which, combined with the action of gravity, caused the film to bend and constitute a vase-shaped surface of great beauty. The Lecturer next referred to the constitution of a liquid vein; he had pointed out, some years ago, a simple mode of observing this constitution by means of the

electric spark; this method corroborated the result before arrived at by Savart, that the lower portion of a liquid vein owes its turbidity to the fact of the mass being there reduced to drops, although the quickness with which they succeed each other gives the eye the impression of continuity. Savart's last experiments on this subject were repeated: a tube about five feet long and two inches wide had a perforated brass disk fixed at its lower extremity; the tube was filled with water, which, after it had become motionless, was permitted to issue from an orifice pierced in the centre of the disk. As the liquid escaped it gave birth to a succession of musical notes of sufficient intensity to be distinctly heard throughout the theatre. That these notes were not due to the motion imparted to the air by the descending drops of the liquid vein was proved, first, by intercepting the vein in its continuous portion, and secondly, by permitting it to discharge itself into a vessel containing water, the orifice being caused to dip beneath the surface of the latter. In this case the mass of liquid was continuous, but the notes were nevertheless produced; thus shewing that the vibrations which produce them must take place in the glass cylinder itself; — and corroborating the conclusions arrived at by Savart from his earliest experiments on this subject. The pitch of the note depends upon the height of the liquid column which produces it; and by attaching a tube of an inch in diameter, furnished with a perforated bottom, to a cylindrical vessel about eighteen inches wide, and filling the whole with water, a note of long duration and of sensibly constant pitch was obtained.

The Lecturer concluded with an experimental illustration of the total reflexion of light at the common surface of two media of different refractive indices. The tube communicating with the reservoir before referred to was fitted into the top of a small box, into one of the sides of which was fitted a glass tube three quarters of an inch wide and five inches long. The side of the box opposite to that through which the glass tube was introduced was of glass. Behind the box was placed a camera, by means of which the electric light could be condensed and caused to pass, first through the glass back of the box, and then through the tube in front, so as to form a white disk upon a screen held in the direct path of the light. When, however, the cock was turned so as to permit water to spout from the tube, the light on reaching the limiting surface of air and water was totally reflected, and seemed to be washed downward by the descending liquid, the latter being thereby caused to present a beautiful illuminated appearance.

[J. T.]

## WEEKLY EVENING MEETING.

Friday, May 26,

SIR HENRY HOLLAND, Bart., M.D., F.R.S., Vice-President, in the Chair.

B. C. BRODIE, Esq., F.R.S.

*On Melting Points.*

WHEN the temperature of certain substances is raised, they pass from the solid to the fluid and from the fluid to the gaseous condition. These transitions are attended with the absorption of heat. There are other bodies which by elevation of temperature undergo a transformation of a different kind. Thus, when liquid phosphorus is heated, in such a manner that its change into the gaseous condition is prevented, at a certain temperature it becomes solid, and passes into the red modification; these allotropic changes also are invariably attended with evolution or absorption of heat.

Considerable anomalies are found in the statements which different experimenters have made as to the melting point of sulphur. The cause of these discrepancies lies in the facility with which the allotropic condition of sulphur is altered by heat. The melting point of octohedral sulphur lies very close upon the point at which it undergoes a change into the oblique-prismatic condition. When this sulphur has been melted, it passes more or less completely into a third allotropic form. For these reasons, the melting point taken was never that of a *pure* sulphur. However, by certain precautions in experimenting, the true melting points of sulphur have been ascertained.

The experiment cannot be made in the usual manner of taking a melting point, namely, by placing a thermometer in the fluid substance, and observing the point of solidification. Fluid sulphur is always a mixture of more than one modification. The experiment is made by placing minute fragments of sulphur in thin glass-tubes, immersing the tubes in a bath of dilute sulphuric acid, and observing the temperature of the fluid at the melting of the substance. Experiments thus conducted have shewn that the melting point of octohedral sulphur is 114·5° C. and of the oblique sulphur 120°C. This latter sulphur is obtained in a pure condition by heating the octohedral sulphur at a temperature below its melting point, from 100° to 110° C. This change invariably takes place when the sulphur is exposed, even momentarily, to this temperature in a state of powder.

The solidifying point of melted sulphur varies according to the

temperature to which it has been raised in the melted condition. Powdered sulphur, carefully melted so as not to raise its temperature above one degree beyond its melting point, will solidify precisely at its melting point, 120° C. If, however, the temperature be raised to 300° C. it will solidify at about 110° C. The cause of this difference is, that the sulphur in the latter case always contains a large portion of a third modification, namely, the viscid form of sulphur.

There are some remarkable anomalies in melting points which do not so readily as the above admit of explanation. Under certain circumstances drops of sulphur will remain in the liquid condition at a temperature far below the true point of solidification, and solidify instantaneously when touched. The same is the case with phosphorus. Water contained in a capillary tube may be immersed without freezing in a mixture cooled to—110° C. The same experiment may be made with a considerable quantity of water if the surface be protected by a thin layer of æther. In these cases the water instantly freezes by agitation or by touching the surface with a solid body. Similar observations have been made in the crystallization of certain salts. A solution of sulphate of soda made at 30° or 40° C. will not crystallize on cooling, provided the fluid be not disturbed, but instantly crystallizes on touching the surface with a wire. This phenomenon does not take place with all solutions. A solution of nitre crystallizes normally. There is also a difference of degree in this property. A solution of borax will remain in an open flask in the supersaturated condition, and crystallizes only on violent agitation.

An experiment was shewn by which a connexion was established between this class of facts and those of which mention was first made. Two tubes were exhibited, each containing the same quantity of sulphur dissolved in the same quantity of bisulphide of carbon. One tube had crystallized in the normal manner, the other had deposited no crystals. The sulphur had in both tubes been dissolved at the same time and in the same manner. But the tube in which the sulphur did not crystallize had been exposed to a higher temperature than the other tube. In this case therefore it was evident that the cause of the supersaturated condition was an alteration of the substance induced by heat. On breaking the point of the tube and agitating the fluid with a wire, the sulphur instantly crystallized. The analogy was pointed out of the sudden alteration of this condition by agitation and contact, and the decomposition which many chemical substances, such as the iodide of nitrogen, undergo by similar causes.

[B. C. B.]

## WEEKLY EVENING MEETING,

Friday, June 2.

WILLIAM ROBERT GROVE, Esq., Q.C., F.R.S., Vice-President, in the Chair.

DR. E. FRANKLAND, F.R.S.

*On the dependance of the Chemical properties of Compounds upon the Electrical character of their constituents.*

THE Lecturer first directed attention to the remarkable continuity and correlation of the natural forces, owing to which, the philosopher, seeking to eliminate the effects legitimately due to each, frequently experienced the greatest difficulty in separating the true results of a single force, from the cognate influence of other forces. Such difficulties were more especially encountered in the manifestations of the chemical force or chemical affinity, which rarely or never acted singly and alone, but was constantly accompanied, modified, and controlled, by collateral forces, which alternately exalted, depressed, or altogether inverted it.

The powerful influence of cohesion and heat especially attracted the attention of Berthollet, and so impressed that profound philosopher with their potency, as to lead him to ignore completely the existence of a separate chemical force. Notwithstanding the otherwise singularly ingenious and sound conclusions of this chemist, the Lecturer believed that later researches had demonstrated the total denial of a distinct chemical force to be untenable.

The influence of electricity upon chemical affinity was perhaps even still greater than that of cohesion or heat; the most powerful combinations being broken up by this agent, if its operations were favoured by the two conditions — mobility of particles (fluidity), and conductibility of the electric current. The phenomenon of the evolution of the separate elements of a binary compound, at the opposite poles of the decomposing cell, was one of the most remarkable attending the resolution of compounds into their elements by the electrical force. It immediately attracted the attention of philosophers, and almost forced upon them the conclusion, that such elements were oppositely electrified.

Davy was the first to seize upon these facts and model them into an electro-chemical theory, which, notwithstanding its defects, was at least as soundly philosophical as those which succeeded it. Davy supposed that the elements in their uncombined condition did not contain free electricity, but that by contact they

became excited. Thus, a particle of sulphur became negative when placed in contact with a particle of copper, which last was simultaneously rendered positive: the application of heat intensified the charge, until at a certain point, the tension of the two electricities became so high, that they suddenly re-combined, carrying with them the molecules of copper and sulphur, which were thus intimately mingled, whilst evolution of heat and light resulted from the combination of the two electricities. Ampère and Berzelius subsequently attempted to remove some of the difficulties, which were encountered in endeavouring to make Davy's theory embrace all chemical phenomena. Ampère considered each element to be permanently endowed with a definite amount of one or the other electricity, being thus invariably either electro-positive or electro-negative to an extent dependent upon the intensity of the charge. Such a naturally charged molecule Ampère imagined to attract around it an atmosphere of the opposite electricity of corresponding intensity, and that when two molecules oppositely charged were brought in contact, their atmospheres of electricity united, giving rise to the heat and light of chemical combination, whilst the original charge retained the attracting molecules in permanent union. Although this theory elucidated some points which Davy's view left unexplained, yet it would not be difficult to start several very serious objections to it: the attempted removal of these gave rise to the electro-chemical theory of Berzelius, who supposed that each element contained the two electricities, but that the one was more powerfully developed than the other, as in the case of a magnet in which one pole, by being divided, was apparently weaker than the other. In chemical combination, Berzelius imagined, that one of the electricities of each element was discharged, producing the heat and light of chemical action, whilst the other was retained and served to hold the elements in combination.

But these attempts of Ampère and Berzelius to improve the theory of Davy succeeded perhaps less in perfecting our views of electro-chemical phenomena, than in demonstrating the necessity for much further research, before these phenomena could be satisfactorily interpreted; for these theories, in which different degrees of affinity were explained by differences in the degree of electrical excitement, have been proved radically defective by the remarkable discovery of Professor Faraday, that compounds, whose elements were united by the most dissimilar degrees of affinity, required equal quantities of electric force for their decomposition.

Such defects in the attempts to account for chemical phenomena by electrical agency led Dumas and other chemists to reject altogether the idea of electro-chemical combination. Dumas regarded a chemical compound as a group of molecules connected by a single force in a manner analogous to a planetary system, and the chemical character of a compound as dependant upon the position

of the separate molecules, and not upon their individual character. This beautiful and highly poetical view would neither have received such an extensive adoption, nor have been the parent of such numerous and brilliant discoveries in the organic portion of the science, if it had not contained a profound truth: nevertheless the Lecturer conceived that the total abnegation of the influence of the electrical character of elements upon the chemical properties of their compounds, implied by this theory of types, was directly opposed to many of the phenomena of chemical combination, which invariably revealed such a connection.

The effect of successive additions of oxygen to an electro-positive element, in gradually weakening its basic, and consequently electro-positive, qualities, and finally converting it into an acid, or electro-negative body, was well known in the case of manganese, iron, chromium, gold, &c., but the effects of the juxtaposition of two or more elements of similar electrical character had not hitherto been much studied. Granting the existence of an electrical charge associated with the molecules of matter, it was evident that such a union of atoms, as that just mentioned, would resemble two approximated globes similarly electrified. Now the effect of the approximation of two such globes would be the intensification of the charge of each; and therefore, if there were any connection between electrical and chemical character, it would be exemplified by an increased energy of affinity under such circumstances. Examples of such an approximation of atoms of similar character were not wanting, even amongst inorganic bodies: thus the compounds of chlorine with oxygen were remarkable instances of the union of like atoms; and we saw in several of them the truth of the foregoing proposition fully borne out. Hypochlorous, chlorous, and chloric acids were all distinguished by the intense energy of their affinities and contrasted strongly with the compounds of oxygen or chlorine with electro-positive elements.

The compounds of phosphorus with hydrogen also exemplified the same effect. Phosphorus, though usually regarded as an electro-negative body, was yet far more closely associated in its general character with the metals than with the metalloids; we were therefore entitled to regard a compound of this element with hydrogen, as a juxtaposition of two similarly electrified atoms. Now two of the compounds of phosphorus with hydrogen, viz. bin-hydride and ter-hydride of phosphorus, were remarkable for the intensity of their affinities, the one being spontaneously inflammable and the other merely requiring a diminution of pressure, when mixed with atmospheric air or oxygen, to determine its combustion.

But the influence of the electrical character of elements upon the chemical properties of their compounds was perhaps most strikingly seen in the behaviour of the organo-metallic bodies, nearly all of which had only recently been discovered. Most of these bodies, which, in their isolated condition, consisted of two or more simi-

larly electrified atoms, were distinguished by an intensity of affinity affinity which was quite foreign to their proximate, or even elementary, constituents. Zinc and methyl, for instance, were neither of them distinguished for any remarkable energy of affinity in their free state; but united as zinc-methylium, they formed a compound whose combining energy surpassed that of all known bodies, and this behaviour was shared in also by the corresponding compounds of zinc with ethyl and amyl. In cacodyl, stanethylium, stibethylium, and the new compounds of arsenic with ethyl, we had additional and striking evidence of the same law, for the affinities of arsenic, tin, and antimony, were, in these compounds, exalted in a most remarkable manner by the approximation of similarly electrified atoms.

These examples seemed to prove clearly the great influence of the electrical character of elements upon the chemical properties of their compounds; but further study of the subject also revealed the paramount influence of molecular structure, which modified and controlled the effects of electrical character, and limited all affinity however heightened by electric induction. To this effect of molecular arrangement was no doubt to be attributed the occurrence of some apparent anomalies which, at first sight, appeared to contradict the general law just laid down, such as perchloric acid, biphosphide of hydrogen, &c.; but the pursuit of the subject into this ramification would have far exceeded the limits of the lecture, the chief object of which was to point out that, although all the electro-chemical theories hitherto proposed were far from satisfactory, yet, that amongst the factors of chemical action, the electrical character of elements could not be denied a place, without ignoring and leaving unexplained some of the most remarkable of chemical phenomena. [E. F.]

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## GENERAL MONTHLY MEETING,

Monday, June 5.

WILLIAM WILBERFORCE BIRD, ESQ., Vice-President, in the Chair.

George J. Lyons, Esq.
Charles Roderick Macgrigor, Esq., and
The Rev. Thomas George Alfred Rushton, B.A., F.S.A.

were duly *elected* Members of the Royal Institution.

John Ferguson, M.D.

was *admitted* a Member of the Royal Institution.

The Secretary read the following Report from the Managers:—

"THE MANAGERS have the gratification of reporting to the Members an act of munificence greatly enhanced in value by special circumstances.

"On Friday last the Secretary received the following letter from Mr. J. Pepys:

"8, *Berkeley Street, 2nd June*, 1854,

"MY DEAR SIR,

As Honorary Secretary to the Royal Institution I trouble you with the following.

"I find I have belonged to the Royal Institution since the month of March 1800 (now more than fifty-four years); and having received during that period much mental gratification and pleasure, I wish to make some small return for the entertainment I have enjoyed; I therefore enclose a draft for One hundred pounds, to be disposed of in any way the Managers may think most to the advantage of this most excellent Institution, of which *I believe* I am now the oldest living Associate. With the earnest wish for its lasting prosperity, I remain much yours, JOHN PEPYS.

"This is the Fifth Donation to the same amount bestowed by the same generous Member. On the four previous occasions, however, the recipient of Mr. Pepys's bounty was in a condition very different from the present.

"At that time the reputation of the Royal Institution was, indeed, rapidly advancing; but neither its high character nor its increasing usefulness prevented this society from being almost overwhelmed by pecuniary difficulties. Such was the period chosen by Mr. Pepys for making those large donations which powerfully contributed to rescue the Institution from absolute ruin.

"The Managers therefore feel that this long-tried friend is entitled to the two-fold credit of having first sustained the society to which he has so long been attached in the hour of its adversity, and of having now added increasing efficiency to its present condition of prosperity and success."

It was then moved by Professor Faraday, seconded by Dr. Webster, and RESOLVED unanimously,—

"That the hearty thanks of this Meeting be presented to JOHN PEPYS, Esq., for the present proof of his good will and effectual support; which is only one of many equally striking instances of his earnestness in the cause of the Royal Institution, exerted in times both of adversity and prosperity extending through a period of half a century."

The following PRESENTS were announced, and the thanks of the Members returned for the same:—

FROM

*Astronomical Society, Royal*—Monthly Notices, Vol. XIV. No. 6. 8vo. 1854.
*Bell, Jacob, Esq.*—Pharmaceutical Journal, June, 1854. 8vo.

*Boosey, Messrs.* (*the Publishers*) — The Musical World for May, 1854. 4to.
*British Architects, Royal Institute of* — Proceedings in May, 1854. 4to.
*Camden Society* — Promptorium Parvulorum, sive Clericorum Lexicon Anglo-Latinum Princeps, recensuit A. Way. Tom. II. 4to. 1853.
*Chiosso, Captain* (*the Author*) — Gymnastics an Essential Branch of National Education. 8vo. 1854.
*Civil Engineers, Institution of* — Proceedings in May, 1854. 8vo.
*De Paravey, Chevalier* (*the Author*) — Du Pays primitif du Ver à soie. 8vo. 1851.
*East India Company, the Hon.* — Bombay Magnetical and Meteorological Observations in 1850. 4to. 1853.
General Report of the Administration of the Punjab, for 1849-51. (With Maps.) fol. 1854.
*Editors* — The Medical Circular for May, 1854. 8vo.
The Athenæum for May, 1854. 4to.
The Practical Mechanic's Journal, for June, 1854. 4to.
The Mechanics' Magazine, for May, 1854. 8vo,
The Journal of Gas-Lighting, May, 1854. 4to.
Deutscher Athenäum, May, 1854. 4to.
*Faraday, Professor, D.C.L., F.R.S.* — Monatsbericht der Königl. Preuss. Akademie, März, 1854. 8vo. Berlin.
*Franklin Institute of Pennsylvania* — Journal, Vol. XXVII. No. 5. 8vo. 1854.
*Geological Society* — Quarterly Journal. No. 38. 8vo. 1854.
*Graham, George, Esq. Registrar-General* — Weekly Reports of the Registrar-General, for May, 1854. 8vo.
Census of Great Britain, 1851.—Education: England and Wales,— Report and Tables. 8vo. 1854.
——— Religious Worship and Education: Scotland; Report and Tables. 8vo. 1854.
*Granville, Rev. A. K. B., M.A.* (*the Author*) — Deptford Worthies, a Lecture. 8vo. 1854.
*Hood, W. Charles, M.D.* (*the Author*) — Suggestions for the Future Provision of Criminal Lunatics. 8vo. 1854.
*Howard, Luke, Esq. F.R.S.* (*the Author*) — Papers on Meteorology. 4to. 1854.
*Jones, Henry Bence, M.D., F.R.S., M.R.I.* (*the Editor*) — A Manual of Elementary Chemistry, by George Fownes, F.R.S. Fifth Edition. Edited by Drs. Bence Jones and Hofmann. 16mo. 1854.
*Lovell, E. B. Esq.* (*the Editor*) — The Monthly Digest for May, 1854. 8vo.
The Common Law and Equity Reports, Part 13. 8vo. 1854.
*Macloughlin, David, M.D., M.R.I.* (*the Author*) — Result of an Inquiry into the Invariable Existence of a Premonitory Diarrhœa in Cholera. 8vo. 1854.
*Noad, H. M., Ph. D., M.R.I.* (*the Author*) — Lectures on Chemistry in connection with Agriculture. 8vo. 1850.
*Novello, Messrs.* (*the Publishers*) — The Musical Times, June, 1854. 4to.
*Photographic Society* — Journal, No. 17. 8vo. 1854.
*Royal Society of London* — Proceedings, Vol. VII. No. 102. 8vo. 1854.
*Society of Arts* — Journal for May, 1854. 8vo.
*Statistical Society* — Journal, Vol. XVII. Part 2. 8vo. 1854.
*Taylor, Rev. W., F.R.S. M.R.I* — Magazine for the Blind, June, 1854. 4to.
Historical Sketch of the Bristol Asylum for the Blind. 16mo. 1854.
*Tyndall, John, Ph. D., F.R.S.* (*the Author*) — On the Vibrations and Tones produced by the contact of Bodies having different Temperatures. (From Phil. Trans. Roy. Soc.) 4to. 1854.
*Welton, T. A. Esq.* (*the Author*) — Freedom in America: its Extent and Influence. 8vo. 1854.

## WEEKLY EVENING MEETING.

Friday, June 9.

SIR HENRY HOLLAND, Bart., M.D., F.R.S., Vice-President, in the Chair.

PROFESSOR FARADAY, D.C.L., F.R.S.

*On Magnetic Hypotheses.*

THIS discourse, the purpose of which was to direct the attention of the audience to the different hypothetical attempts made to account physically for the known properties of matter in relation to its magneto-electrical phenomena, followed on very naturally to that of Dr. Frankland on the 2nd instant, who then gave an account of the different views advanced by Davy, Ampère, and Berzelius, of the manner in which electricity might be associated with the atoms or molecules of matter, so as to account for their electro-chemical actions, and of the logical and experimental objections which stood in the way of each. On the present occasion reference was first made to Coulomb's investigations of mutual magnetic actions; to the hypothesis advanced by him, that two magnetic fluids, associated with the matter of magnetic bodies, would account for all the phenomena; and to Poisson's profound mathematical investigation of the sufficiency of the hypothesis. Then Oersted's discovery of the relation of common magnetism to currents of electricity was recalled to mind:—hence an enormous enlargement of the scope of magnetic force and of our knowledge of its actions; and hence Ampère's beautiful investigations, and his hypothesis (also sustained by the highest mathematical investigation),—that all magnetic phenomena are due to currents of electricity; and that in such bodies as magnets, iron, nickel, &c. the atoms or particles have naturally currents of electricity running round them in one direction, about what may be considered as their equatorial parts. After Oersted's time, further experimental discoveries occurred; currents of electricity were found competent to induce collateral currents, and magnets proved able to produce like currents; thus shewing the identity of action of magnets and currents in producing effects of a kind different to ordinary magnetic attractions and repulsions. Then diamagnetism was discovered, in which actions analogous to those of ordinary magnetism occurred, but with the antithesis of attraction for repulsion and repulsion for attraction: and these were so extensive, that whatever bodies were not magnetic proved to be diamagnetic; and thus *all* matter was brought under the dominion of that magnetic force, whose physical mode of action

hypothesis endeavours to account for. As the hypothesis of Ampère could not account for diamagnetic action, some assumed that magnetic and electric force might, in diamagnetic matter, induce currents of electricity in the reverse direction to those in magnetic matter; or else might induce currents where before there were none: whereas in magnetic cases it was supposed they only constrained particle-currents to assume a particular direction, which before were in all directions. Weber stands eminent as a profound mathematician who has confirmed Ampère's investigations as far as they proceeded, and who has made an addition to his hypothetical views; namely, that there is electricity amongst the particles of matter, which is not thrown into the form of a current until the magnetic induction comes upon it, but which then assumes the character of current, having a direction the contrary to that of the currents which Ampère supposed to be always circulating round magnetic matter; and so these other matters are rendered diamagnetic.

De la Rive, who has recently most carefully examined the various hypotheses, and who as an experimentalist and discoverer has the highest right to enter into the consideration of these deep, searching, and difficult enquiries, after recalling the various phenomena which shew that the powers concerned belong to the particles of matter and not to the masses merely, (the former conferring them by association upon the latter,) then distinguishes magnetic action into four kinds or modes,—namely, the ordinary, the diamagnetic, the induction of currents, and the rotation of a ray; and points out that any acceptable hypotheses ought to account for the *four* modes of action, and, it may be added, ought to agree with, if not account for, the phenomena of electro-chemical action also. De la Rive conceives that as regards these modes of action this hypothetical result may be obtained, and both Ampère and Weber's views also retained in the following manner. All the atoms of matter are supposed to be endowed with electrical currents of a like kind, which move about them for ever, without diminution of their force or velocity, being essentially a part of their nature. The direction of these currents for each atom is through one determinate diameter, which may therefore be considered as the axis. Where they emerge from the body of the atom they divide in all directions, and running over every part of the surface converge towards the opposite end of the axis diameter, and there re-enter the atom to run ever through the same course. The converging and diverging points are as it were poles of force. Where the atoms of matter are close or numerous in a given space, (and chemical considerations lead to the admission of such cases,) the hypothesis then admits that several atoms may conjoin into a ring, so that their central or axial currents may run one into the other, and not return as before over the surface of each atom: these form the molecules of magnetic matter, and represent Ampère's hypothesis of molecular currents.

Where the atoms, being fewer in a given space, are farther apart, or where, being good conductors, the current runs as freely over the surface as through the axis, then they do not form like groups to the molecules of magnetic matter, but are still considered subject to a species of induction by the action of external magnets and currents; and so give rise to Weber's reverse currents. The induction of momentary currents and the rotation of a ray are considered by De la Rive as in conformity with such a supposition of the electric state of the atoms and particles of matter.

The Lecturer seemed to think that the great variety of these hypotheses and their rapid succession was rather a proof of weakness in this department of physical knowledge than of strength, and that the large assumptions which were made in turn for each should ever be present to the mind. Even in the most perfect of them, *i. e.* De la Rive's, these assumptions are very considerable; for it is necessary to conceive of the molecules as being flat or disc-like bodies, however numerous the atoms of each may be; also that the atoms of one molecule do not interfere with or break up the disposition of those of another molecule; also that electro-chemical action may consist with such a constituted molecule; also that the motive force of each atom current is resident in the axis, and on the other hand that the passage of the current over the surface offers *resistance;* for unless there were a difference between the axial and the surface force in one direction or the other, the atoms would have no tendency to congregate in molecules. In making these remarks, however, the speaker had no thought of depreciating hypothesis or objecting to its right use. No discoverer could advance without it; and such exertions as those made by De la Rive, to bring into harmony thoughts which in their earlier forms were adverse to each other, were of the more value, because they were the exertions of a man who knew the value both of hypothesis and of laws, of theory and of fact, and had given proofs of the power of each by the productions of his own mind. Still the speaker advocated that mental reservation which kept hypothesis in its right place and which was ready to abandon it when it failed; and as examples referred to Newton, who (as is shewn by his Letters to Bentley) had very strong convictions of the physical nature of the lines of gravitating force, yet in what he publicly advanced stopped short at the law of action of the force, and thence deduced his great results;— and also to Arago, who, discovering the phenomena of magnetic rotation, yet not perceiving their physical cause, had that philosophic power of mind which enabled him to refrain from suggesting one.

[M. F.]

## GENERAL MONTHLY MEETING,

### Monday, July 3.

William Wilberforce Bird, Esq., Vice-President, in the Chair.

R. W. Blencowe, Esq.
John M. Heathcote, Esq.
Thomas Sopwith, Esq., and
Robert Stephenson, Esq., M.P., F.R.S.

were duly *elected* Members of the Royal Institution.

The following Presents were announced, and the thanks of the Members returned for the same :—

FROM

*Airy, G. B. Esq, F.R S., Astronomer Royal* — Regulations of the Royal Observatory, Greenwich. 4to. 1853.
Report of the Astronomer-Royal, June 3, 1854. 4to. 1854.
*Antiquaries of London, Society of* — Archæologia, Vol. XXXV. Part 2. 4to. 1854.
Proceedings, Nos. 37—40. 8vo. 1853-4.
List of Fellows. 8vo. 1854.
*Asiatic Society of Bengal* — Journal, No. 239. 8vo. 1854.
*Astronomical Society, Royal* — Monthly Notices, Vol. XIV. No. 7. 8vo. 1854.
*Author* — A Few words on Popery and Protestantism. By a Layman. 12mo. 1854.
Classical Instruction: its Use and Abuse. 12mo. 1854.
*Bell, Jacob, Esq., M.R.I.* — Pharmaceutical Journal, July, 1854. 8vo.
*Bombay Branch of the Royal Asiatic Society* — Journal, No. 19. 8vo. 1854.
*Boosey, Messrs. (the Publishers)* — The Musical World for June, 1854. 4to.
*Blunt, John Elijah, Esq., M.A., M.R.I. (the Author)* — History of the Jews in England. 8vo. 1830.
*British Architects, Royal Institute of* — Proceedings in June, 1854. 4to.
*East India Company, the Hon.* — Ladák, Physical, Statistical, and Historical; with Notices of the Surrounding Countries. By Major Alex. Cunningham, (With Map and Plates.) 8vo. 1854.
The Bhilsa Topes, or Buddhist Monuments of Central India: comprising a Brief Historical Sketch of Buddhism, by Major Alex. Cunningham. 8vo. 1854.
Physical Geography of Western Thibet, by Capt. H. Strachey. With Map, 8vo. 1854.
Sakuntalá, a Sanskrit Drama, by Kalidasa. Edited by Monier Williams, M.A. 8vo. 1853.
The Prákrita-Prakása: or the Prákrit Grammar of Vararuchi. The Text; with an English Translation, Notes, &c., by E. B. Cowell. 8vo. 1854.

*Editors* — The Medical Circular for June, 1854. 8vo.
The Athenæum for June, 1854. 4to.
The Practical Mechanic's Journal for July, 1854. 4to.
The Mechanic's Magazine for June, 1854. 8vo.
The Journal of Gas-Lighting, June, 1854. 4to.
Deutsches Athenäum, June, 1854. 4to.

*Faraday, Professor, D.C.L., F.R.S.*— Monatsbericht der Königl. Preuss. Akademie, April, 1854. 8vo. Berlin.

*French, J. G. Esq.* (*the Author*) — The Nature of Cholera Investigated. 2nd edition. 8vo. 1854.

*Graham, George, Esq., Registrar-General* — Weekly Reports of the Registrar-General, for June, 1854. 8vo.

*Holdship, John, Esq., M.R.I.* — More Worlds than one, the Creed of the Philosopher and the Hope of the Christian. By Sir David Brewster, D.C.L., F.R.S. 16mo. 1854.

*Jablonowskischen Gesellschaft zu Leipzig* — Dr. J. Zech: Astronomische Untersuchungen über die wichtigeren Finsternisse, welche von den Schriftstellern des classischen Alterthums erwähnt werden. 8vo. 1853.

*Londesborough, Lord, K.C.H., M.R.I.* — Miscellanea Graphica: a collection of Ancient, Mediæval, and Renaissance Remains in the possession of Lord Londesborough. Part 1. 4to. 1854.

*Lovell, E. B. Esq., M.R.I.* (*the Editor*)— The Monthly Digest for June, 1854. 8vo.
The Common Law and Equity Reports, Part 14. 8vo. 1854.

*Medical Board of Bombay* — Deaths in Bombay during 1852. 8vo. 1853.

*Novello, Mr.* (*the Publisher*) — The Musical Times for July 1854. 4to.

*Photographic Society* — Journal, Nos. 18, 19. 8vo. 1854.

*Quaritch, Mr. B.* (*the Publisher*) — A Practical Grammar of the Turkish Language. By W. B. Barker. 16mo. 1854.

*Sächsische Gesellschaft der Wissenschaften zu Leipzig* — Abhandlungen, Band I. II. Bande III. 6 Hefte; Band IV. 6 Hefte. 8vo. 1850—4.
Berichte, 1846—53, and 1854 Heft 1. 8vo.

*Smith, C. Roach, Esq.* — The Faussett Collection of Anglo-Saxon Antiquities. 8vo. 1854.

*Society of Arts* — Journal for June, 1854. 8vo.

*Taylor, Rev. W., F.R.S., M.R.I.* — Magazine for the Blind, July, 1854. 4to.

*University College, London* — The University College, London, Calendar for 1853-4. 8vo. 1854.

*Vereins zur Beförderung des Gewerbfleisses in Preussen* — Verhandlungen, März und April, 1854. 4to. Berlin.

*Ward, N. B. Esq., F.R.S., F.L.S., M.R.I.* — On Wardian Cases for Plants, and their Applications. By Stephen H. Ward, M.D., Lond. 16mo. 1854.

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